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BIG SOUTH FORK
NATIONAL RIVER AND RECREATION AREA
WATER QUALITY REPORT 1982-1984

WATER RESOURCES REPORT NO. 86-7

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
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WATER RESOURCES DIVISION
NATIONAL PARK SERVICE
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523

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Chief
Water Resources Division
National Park Service
301 South Howes
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BIG SOUTH FORK
NATIONAL RIVER AND RECREATION AREA:
WATER QUALITY REPORT 1982-1984

WATER RESOURCES REPORT NO. 86-7

by

Michael Rikard
Big South Fork National River and Recreation Area

Sam Kunkle
Water Resources Division
National Park Service

and

Juliette Wilson
Water Resources Division
National Park Service
Colorado State University

August 1986

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ABSTRACT

Coal mining, oil and gas exploration and extraction, sewage releases, and agricultural activities within the boundaries of Big South Fork National River and Recreation Area are affecting the water quality of its streams. In November, 1982, a water quality monitoring program was initiated in the recreation area to evaluate stream water quality, identify polluted streams, locate major sources of pollution, and determine the background levels of water quality in unaffected streams. Samples were collected at 34 sampling sites on a monthly (or in some cases a bimonthly) basis and were analyzed for 15 parameters, including indicators of acid mine drainage, sewage discharge, and watershed disturbances. This report is a review and analysis of the data collected.

The data gathered for the November 1982 through October 1984 monitoring period allowed grouping of streams into the following five major categories: (1) clean with sandstone basin, (2) clean with limestone basin, (3) slightly polluted, (4) moderately polluted, and (5) severely polluted. The "clean" category streams contained low bacterial counts, low levels of metals, neutral pH values, and low acidity, and they support trout or other fish populations. At the other extreme, the "severely polluted" streams exhibited undesirable concentrations of certain parameters, for example, fecal coliforms in concentrations of several hundred colonies per 100 ml, iron levels above 0.2 mg/L, acidity greater than 30 mg/L, manganese over 0.5 mg/L, and pH values as low as 3.9.

ACKNOWLEDGMENTS

The authors would like to thank Doyle Kline, Glenn Voss, and Mike Duwe for their foresight in recognizing the need for a water quality monitoring program at the Big South Fork NRRA and for their support in developing this program. Appreciation also is extended to Mark Flora for his review of the program and suggestions on monitoring. Special thanks are due the several reviewers whose valuable comments significantly improved the technical integrity of this report. Reviewers include Gary Smillie and Jeff Hughes, National Park Service/Colorado State University; Dr. Edward Buckner, The University of Tennessee; Robert Montgomery, Colorado State University; and Daniel Scheidt, South Florida Research Center, Everglades National Park. Catherine Petit spent long hours typing the many drafts of this report, and we extend to her our special appreciation for her exceptional efforts. Maps were painstakingly hand-colored by Margo Boodakian, Daniel Cowdin, Chuck Flail, and Jeff Hughes. Finally, we wish to thank Sandy Page and Linda Jensen, technical typists, and Ken Streeb, graphic artist, for their diligent work that ultimately rendered the final document.

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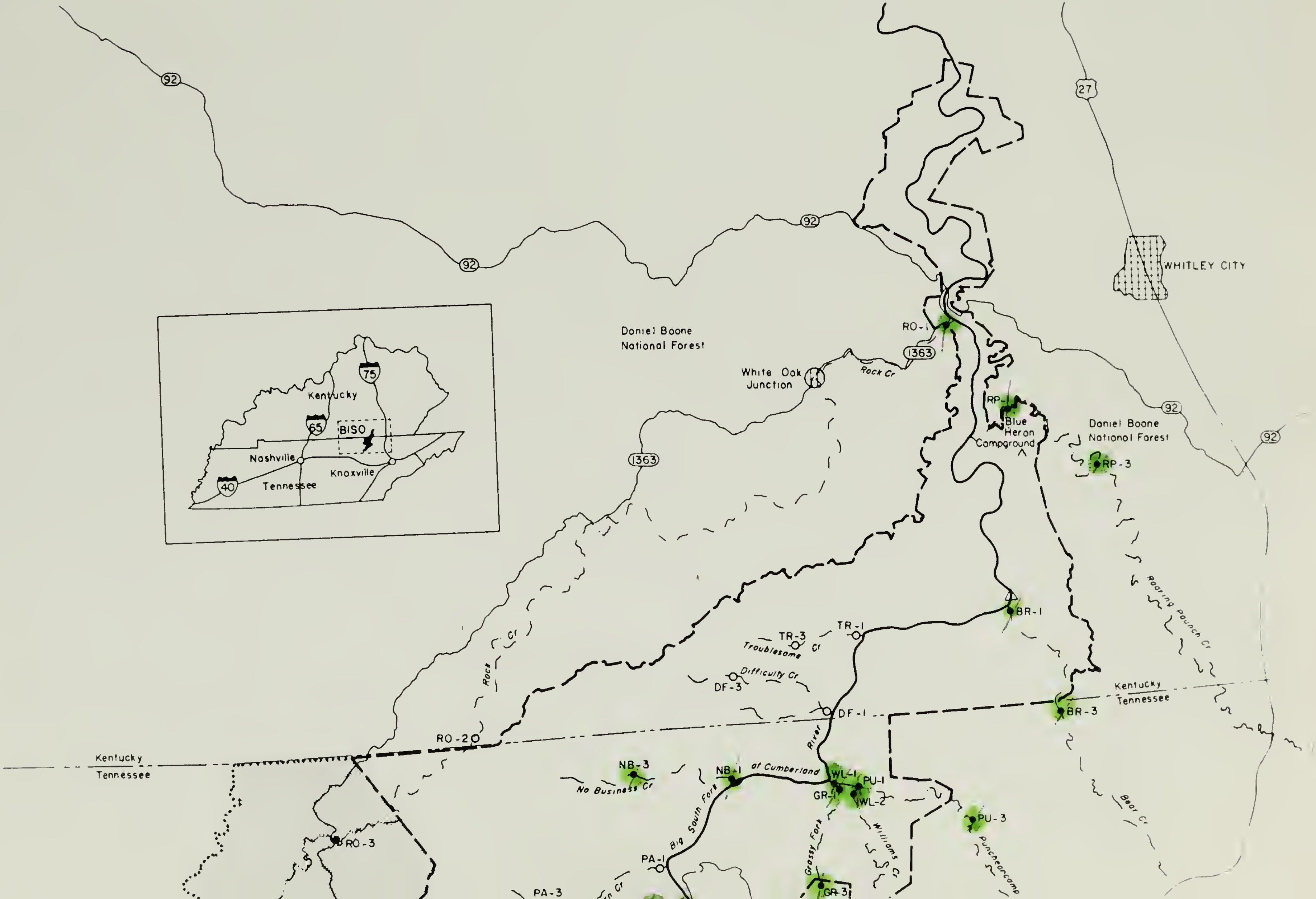
INTRODUCTION

The Big South Fork National River and Recreation Area (BISO), located in northeastern Tennessee and southeastern Kentucky, is a relative newcomer to the National Park Service (Fig. 1). Development of the area began in 1978 following the enabling legislation (Section 108 of the Water Resources Development Act, PL 93-251), which directed the Secretary of the Army, acting through the Chief of Engineers, to establish the area. The National Park Service (NPS) is working with the U.S. Army Corps of Engineers in developing and managing this unique federal recreation unit. While the Corps of Engineers has the initial responsibility for acquiring land and developing all facilities, NPS is responsible for interim management. At project completion, BISO will comprise approximately 49,800 hectares (123,000 acres), and the entire unit will be turned over to the Secretary of the Interior for NPS administration.

Numerous streams of various degrees of water quality flow into the Big South Fork of the Cumberland River, which runs northward from Tennessee into Lake Cumberland, Kentucky. These waterways are being adversely affected by a number of human activities, including coal mining, oil and gas exploration, agricultural and forestry practices, and sewage discharge.

Except for New River and Clear Fork, the tributaries of the Big South Fork of the Cumberland River had not been extensively surveyed for water quality until 1982. In that year, a group from Tennessee Technological University completed a survey of water quality, fish populations, and benthic macroinvertebrates for BISO (O'Bara et al. 1982). The investigators found considerable variation in water quality within


92
27
WHITLEY CITY
Daniel Boone National Forest
RO-1
1363
Rock Cr
White Oak Junction
RP-1
Blue Heron Campground
RP-3
Kentucky
75
65
BISO
Nashville
Knoxville
40
Tennessee
Roaring Paunch Cr
BR-1
TR-1
TR-3
Troublesome Cr
Difficulty Cr
DF-3
DF-1
BR-3
Kentucky
Tennessee
RO-2
River
NB-3
No Business Cr
NB-1
of Cumberland
WL-1
PU-1
GR-1
WL-2
PU-3
Bear Cr
Big South Fork
Grassy Fork
Williams Cr
Puncheoncamp
PA-1
PA-3
GR-3
RO-3
Kentucky
Tennessee

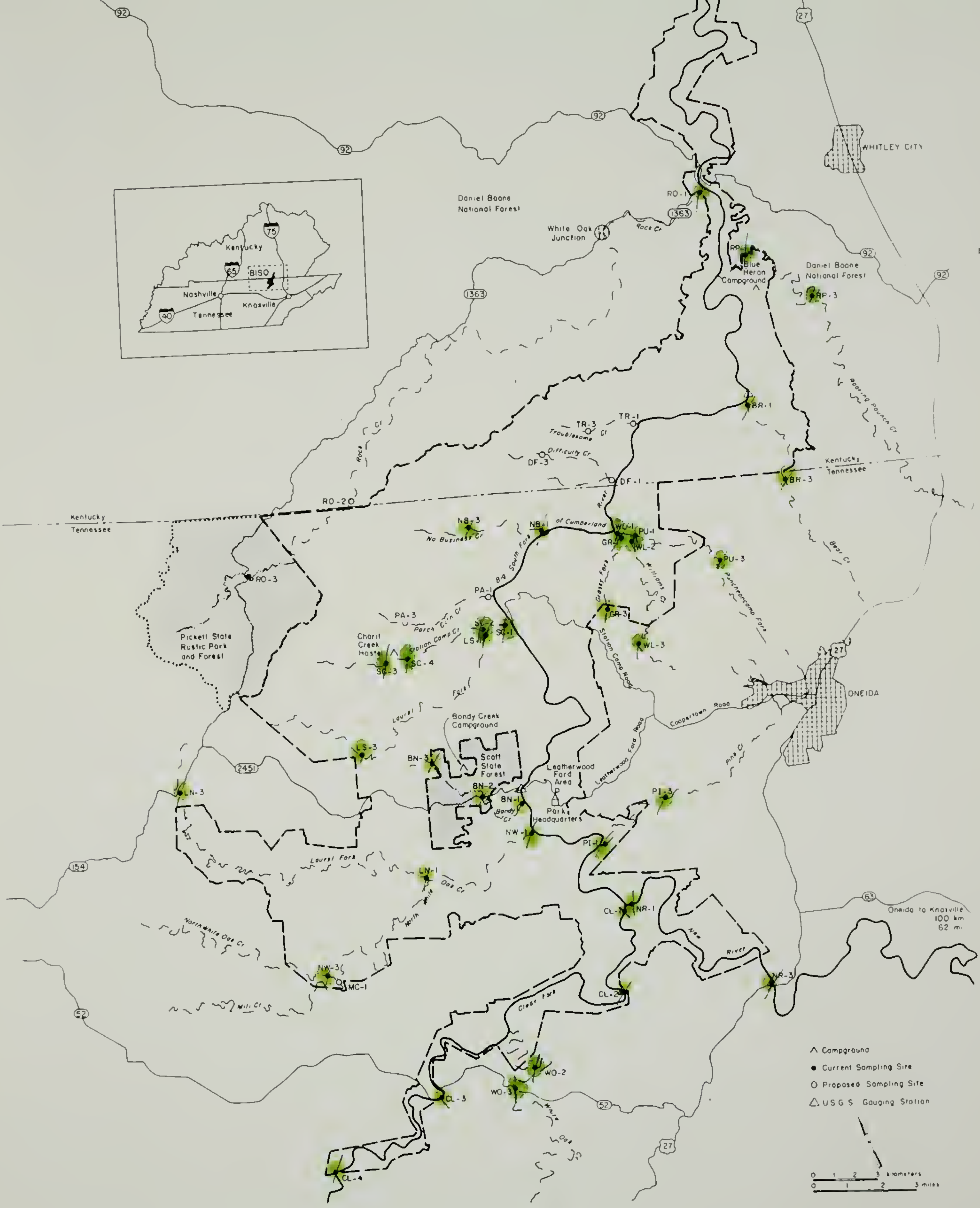


Figure 1. Big South Fork National River and Recreation Area, showing present and proposed sampling sites and relative location in Kentucky and Tennessee (inset).

the recreational area: waters in the western half of the recreation area exhibited natural and undisturbed conditions and associated good water quality, while in the eastern and southern portions of the recreation area, coal mining, forestry and agricultural practices, domestic runoff, and oil and gas exploration were found to have degraded the water quality.

In order to assess the extent of pollution and to gather background data for these streams, a water quality monitoring program was begun at BISO in November of 1982. The resulting data will be used by park management to better protect the water resources of the recreation area. What follows is a report of the results of the first two years of monitoring.

Description of the Area

The Big South Fork National River and Recreation Area (NRRA) presently encompasses 28,330 hectares (70,000 acres) of rugged, steep gorge and adjacent plateau-area woodland (Figs. 2 and 3). This varied terrain produces a diversity of flora and fauna, dominated by mixed-pine/oak-hickory forest, with white pine and hemlock present in cove areas. Wildlife is typical of southeastern U.S. forests and includes white-tail deer, red and grey fox, bobcat, feral hogs, gray squirrel, wild turkey, and ruffed grouse.

The Cumberland Plateau Region of the recreation area is part of the Appalachian Plateau physiographic province of the eastern United States. The Cumberland Plateau is a broad, relatively flat tableland capped with rocks of the Pennsylvanian geologic age. Because this resistant cap rock has prevented the erosion of the underlying softer rocks, the

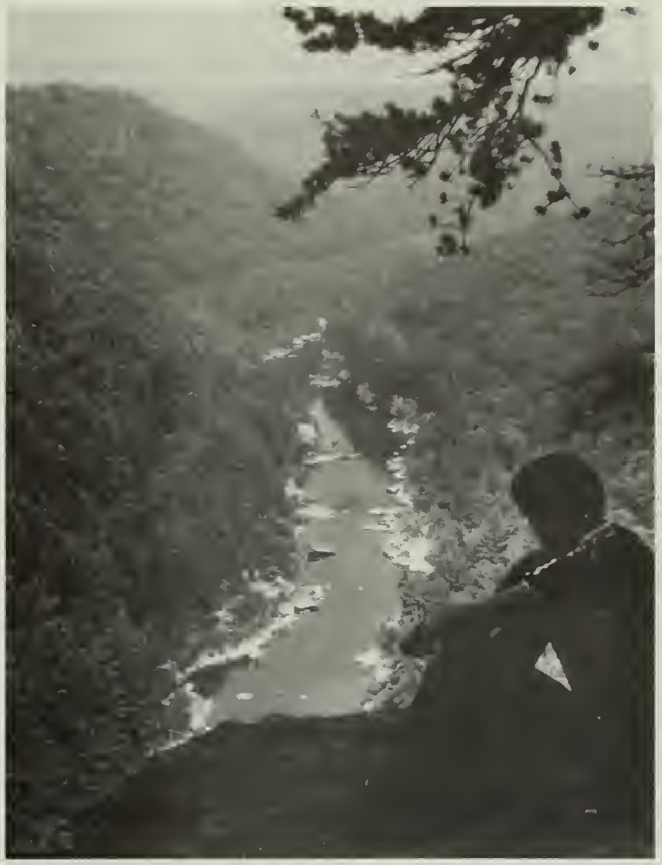


Figure 2. Gorge area of the Big South Fork of the Cumberland River.

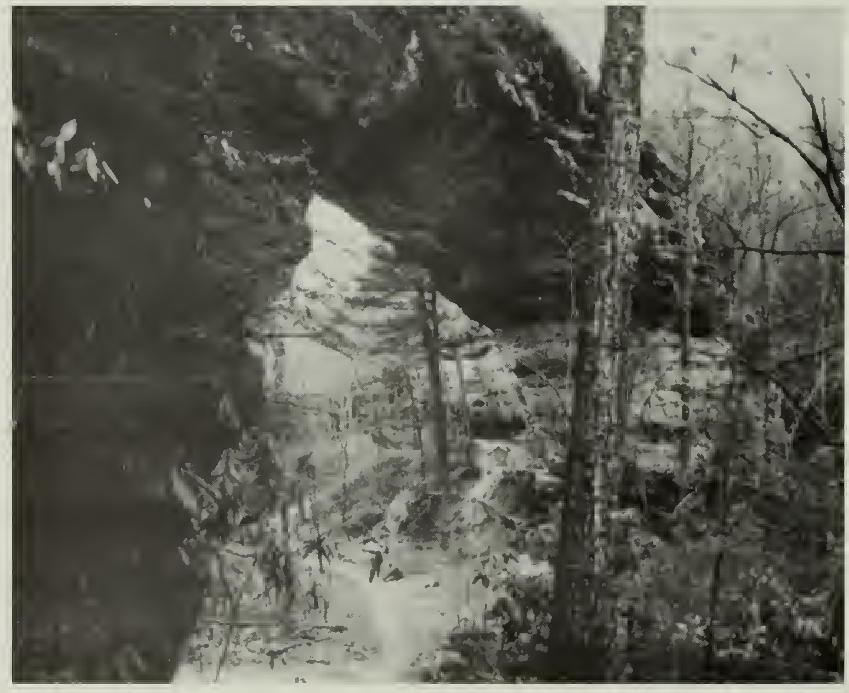


Figure 3. North Arch of Twin Arches, Big South Fork National River and Recreation Area.

surface elevation of between 518 and 610 m (1700 and 2000 ft) above sea level is about 300 m (984 ft) higher than bordering lands (O'Bara et al. 1982). The Big South Fork of the Cumberland River has cut a gorge through this plateau, forming walls 91-122 m (300-400 ft) high.

Based on data collected from 1951-1973, precipitation for the area averages about 127 cm (50 in) per year, ranging from 89 cm (35 in) in dry years to 178 cm (70 in) in wet years. Thunderstorms occur about 45 days per year, often producing locally heavy rainfall and occasional damaging winds and extreme changes in temperature. Annual temperature averages approximately 13°C (56°F); and while extremes seldom exceed 38°C or -21°C (100°F or -6°F), temperatures are above 32°C (90°F) about 40 days during the year. A frost-free season of about 160 days lasts from late April to early October (Gaydos et al. 1982).

Cumberland Plateau soils are derived from sandstone and shale, and the depths of the different soil associations range from 0-254 cm (0-100 in). These well-drained soils are generally low in natural fertility. The steep terrain, with slopes of 20 to 60 percent, has a fairly high potential for erosion problems (Gaydos et al. 1982).

From an analysis of high-altitude aerial photography collected between 1974 and 1976, Gaydos et al. (1982) estimate the Cumberland Plateau in Tennessee to be approximately 75 percent forest, 20 percent agriculture and open land, 3 percent mining, and 2 percent urban or rural residential.

Activities in the Area

BISO is being developed to allow a diversity of outdoor recreational activities, including camping, boating, canoeing, rafting, swimming, hiking, bicycling, horseback riding, picnicking, sightseeing, hunting, and fishing (Fig. 4). The gorge areas are closed to motorized traffic except in designated areas in order to preserve them in a more natural state. However, trails into the gorge areas are being constructed to enhance accessibility by backpackers, day hikers, hunters, fishermen, and others on foot. Adjacent plateau areas are to remain open to jeep and motorcycle traffic. The goal is to maintain BISO in a manner which will allow maximum public use with minimal damage to natural resources.

In contrast to a national park, hunting and fishing are allowed within BISO in accordance with state regulations. The enabling legislation for the recreation area also allows the extraction of oil, gas, and coal from the adjacent Plateau area where mineral rights have been

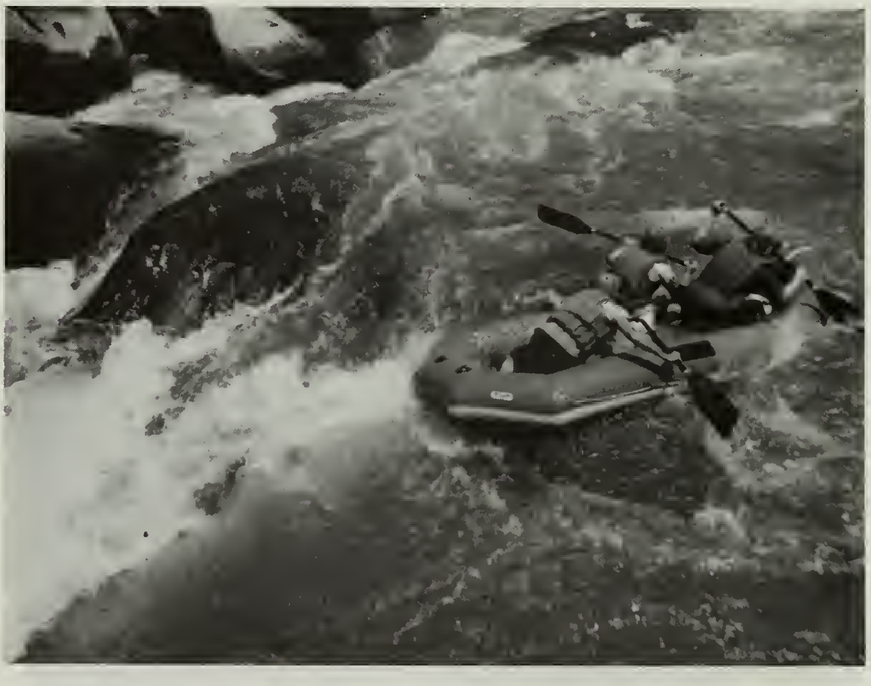


Figure 4. Rafters take on The Ell, a class III rapid.

retained by owners. However, coal extraction is only allowed by deep mining in places where the mine opening can be located outside the boundary of the recreation area. Surface mining or strip mining is prohibited by the enabling legislation. The Federal Coal Leasing Amendments Act of 1976, as amended (90 Stat 1083-1092) and codified in 43 CFR 3400.2(a)(8), prohibits leasing of federally owned coal within the recreation area (privately owned coal can still be removed). Interest from the minerals industry has surfaced regarding the extraction of oil and gas from federally owned mineral rights in the adjacent area, but no formal determination on the matter has been made by either the Department of the Interior or the Department of the Army.

Several small cities lie within a 30-minute drive of the BISO area, all of which have populations of less than 10,000 people. Only a few light industries occur within the BISO watershed, none of which are major water users. Other economic bases for the area surrounding BISO include coal extraction, oil and gas exploration, timber harvesting, and agriculture.

Aquatic Life

The Big South Fork system and surrounding area has a rich diversity of fish species. These have been extensively surveyed and documented in reports by Cope (1870), Kirsh (1893), Comiskey (1970), Comiskey and Etnier (1972), Brazinski (1979), and O'Bara et al. (1982). The 44 species collected by O'Bara et al. (1982) on tributaries in the Big South Fork NRRA are listed in Appendix C.

The tributaries of BISO also support a wide variety of benthic macroinvertebrates. Over 215 taxa existing within BISO have been identified (O'Bara et al. 1982) and are also listed in Appendix C.

Stream Flow Information

The U.S. Geological Survey (USGS) has four gauging stations presently operating within or close to the boundary of the Big South Fork National River and Recreation Area. Discharge and water quality data have been collected at each station for a number of years (Table 1). The station furthest downstream is the South Fork Cumberland River station near Stearns, Kentucky. This station records an average annual flow of 1803 cfs (51 m^3/sec) based on records from 1943-1979 (Fig. 5). Taking the maximum flow observed each month and averaging these maximums over the years of record shows that the largest average maximum flow is 10,580 cfs (300 m^3/sec) and occurs in March. Likewise, the smallest average minimum flow is 210 cfs (6 m^3/sec) and occurs in October. A minimum of 800 cfs (23 m^3/sec) is needed to raft the "gorge"

Table 1. Records available and years collected at four USGS gauging stations in and near the Big South Fork NRRA.

Station	Type of Records[1]	Dates
New River at New River, TN	Discharge data Water quality data	1934-present 1964-1967; 1975-present
Clear Fork near Robbins, TN	Discharge data Water quality data	1930-1971; 1975-present 1963-1964; 1976-1977; 1979-1982; 1984-present
South Fork Cumberland River near Stearns, KY	Discharge data Water quality data	1942-present 1960-1972; 1979-present
South Fork Cumberland River at Leatherwood Ford, TN	Discharge data Water quality data	Established in 1984[2]

[1] Water quality parameters include pH, temperature, dissolved oxygen, turbidity, conductivity, and suspended sediment discharge.

[2] Not fully operational at time of report.

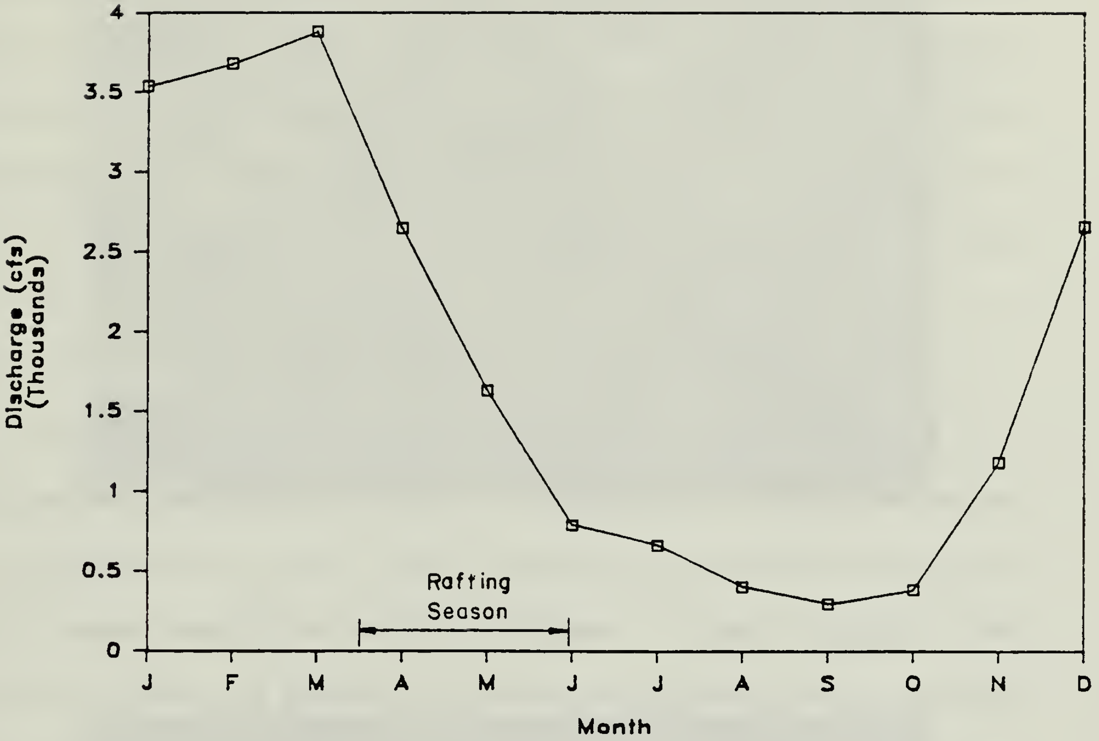


Figure 5. Mean monthly flow for the South Fork of the Cumberland River near Stearns, Kentucky (Period of Record: 1943-1979).

section of the river, and 10,000 cfs (283 m^3/sec) is considered the maximum flow for safe rafting on the river. Ten commercial rafters were licensed in 1984 and conducted raft trips from mid-March to the end of May.

WATER QUALITY AND WATER RESOURCE CONCERNS

Because more than 90 percent of the Big South Fork watershed lies outside NPS boundaries, activities occurring outside the recreation area greatly influence water quality within BISO. Activities influencing BISO waters that are discussed in this section include coal mining, oil and gas drilling, sewage discharge, agricultural and forestry practices, road salting, and garbage disposal.

Coal Mining

Surface and deep mining of coal is a primary source of water pollution in BISO. The BISO area was extensively logged and mined from the early 1900's until the early 1960's, and it contains over 100 deep mine openings as well as several abandoned strip mine areas. (Locations of major mine openings are shown in Appendix D.) Over 40 of these are located along the main stem of the Big South Fork of the Cumberland River in what is known as the Blue Heron area. A project was begun in August, 1984, to close some of the openings for safety reasons and to reclaim a number of spoil sites. Even so, these mines and mine spoil embankments will continue to be a source of acid mine drainage. Several streams already have been seriously affected by acid runoff from both active and abandoned mines (Fig. 6) and by erosion of mine spoils and unimproved dirt roads. The results have been increased sedimentation; high sulfate content; elevated concentrations of dissolved metals such as iron, manganese, and aluminum; low pH; and high conductivity and hardness, as shown by several studies conducted in the vicinity of BISO (Parker and Carey 1980; Dyer 1982a,b; Gaydos et al. 1982). These impacts were corroborated and further detailed by results from the

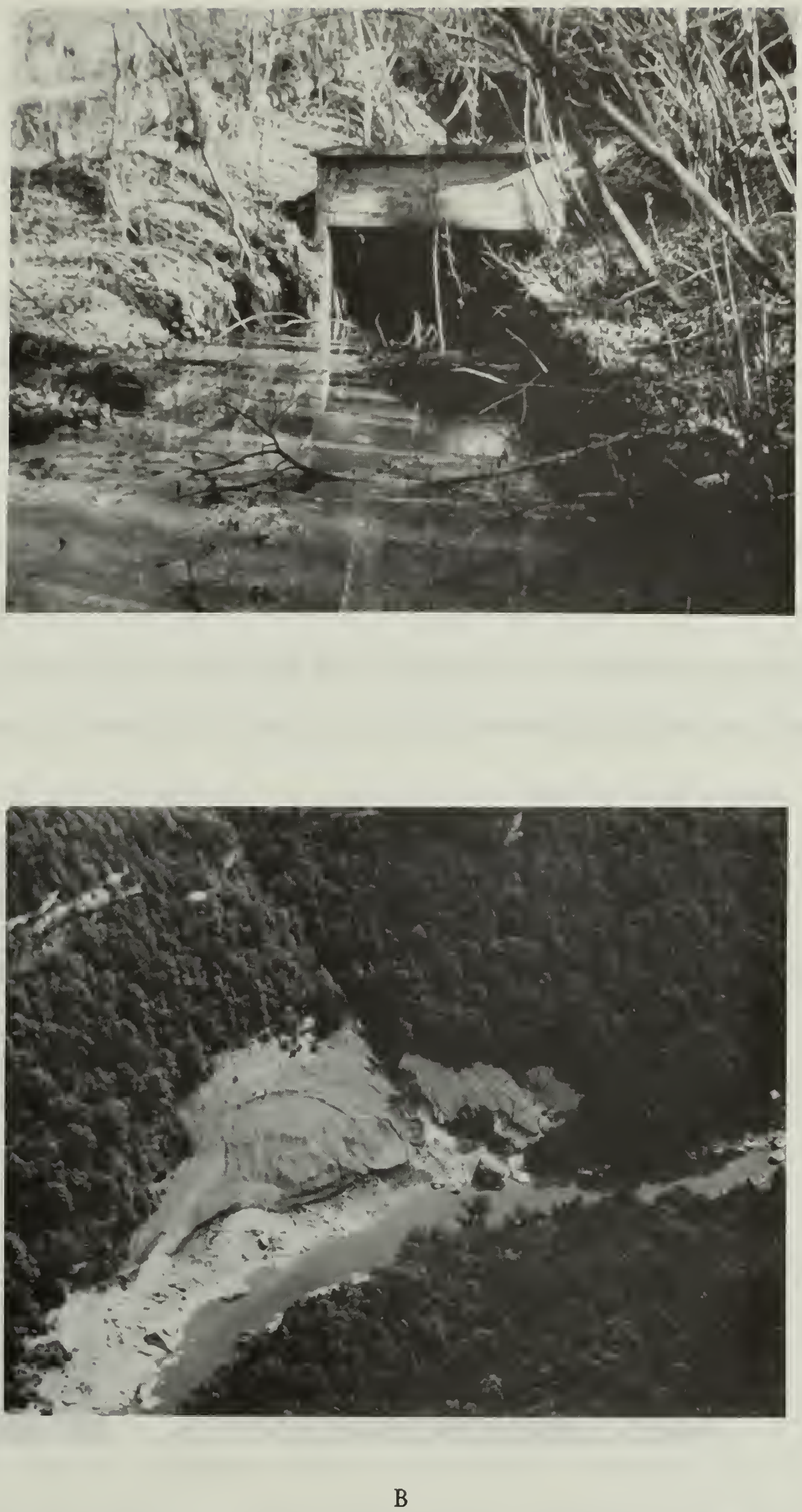


Figure 6. (A) Abandoned deep mine and (B) spoil piles from abandoned strip mines.

present work. Such conditions are not only deleterious to the aquatic life in affected waters, but they reduce a stream's aesthetic values and render it less desirable even for noncontact recreation.

Oil and Gas Exploration and Extraction

Normally, oil and gas exploration only affects nearby waterways during the drilling process, which at BISO averages five to ten days per well. For this reason, the impacts are sporadic and difficult to document, though in these brief periods much damage can be done to the quality of surrounding waters (Fig. 7). A variety of chemicals, including acids and sudsing agents, are used during the drilling process and usually are allowed to run across the surface of the land; or, they are trapped in settling ponds with oil and brine water produced by the

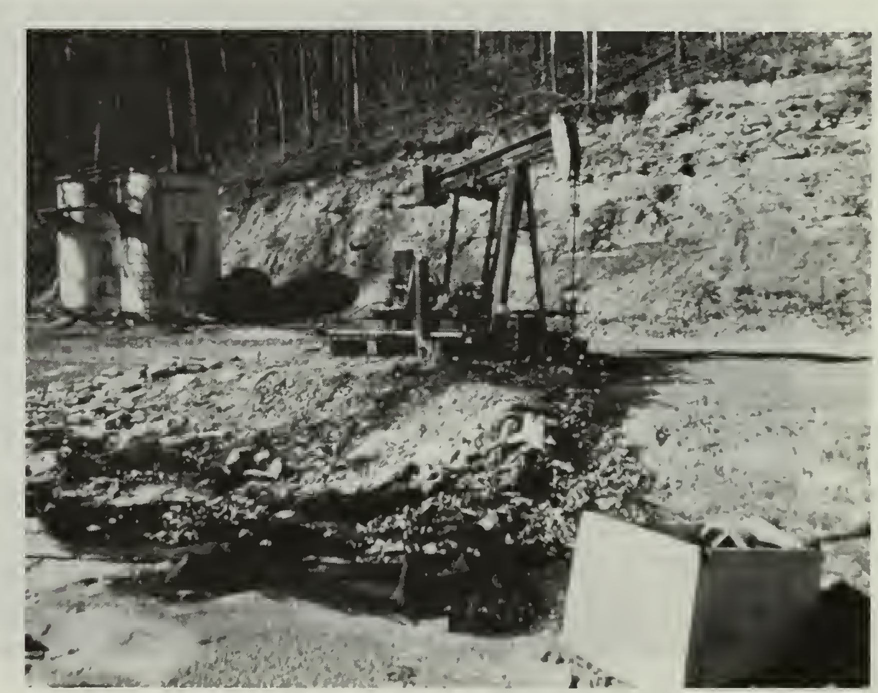


Figure 7. Oil drilling site within the Big South Fork National River and Recreation Area.

drilling process, and these also may be left to run out over the surrounding area. The senior author has witnessed one fish kill in New River suspected to be the result of oil and gas drilling. As with mining, land clearing and road building result in further erosion of soil and, consequently, increased sedimentation in waterways. In view of the fact that over 150 active and abandoned well sites and their network of access roads exist within the boundary of BISO alone, with new sites being drilled each year, the potential exists for adverse impacts on the waters of BISO.

Sewage Discharge

The sewage treatment plant in Oneida, Tennessee, is another source of pollution entering the BISO watershed. Also, many individual households located throughout the area do not have proper sewage treatment facitilies. Taken together, these two situations can contribute to high chloride levels in streams, large populations of bacteria and other pathogens, large amounts of organic matter, low dissolved oxygen levels, reduced aesthetic qualities, and public health hazards. Nutrient enrichment also can result from sewage impacts, although nutrients were not measured in this study.

Agricultural and Forestry Practices and Other Activities

Activities of importance but of lesser overall impact include agricultural and forestry practices, road salting, and inadequate garbage removal. Impacts from agricultural practices (i.e., erosion, fertilization, liming, and runoff from wastes of domestic animals) affect nearby waters by producing elevated levels of conductivity, alkalinity, and hardness. Road salting can increase chloride levels in water, but because it occurs only occasionally in BISO it does not pose a serious threat to water quality. Drainage from inadequate garbage disposal (such as roadside garbage dumps) can have a variety of effects, especially during storms or high flow when the runoff washes this material into the stream channels. One problem that results from several different human activities is erosion. Whether it enters a watercourse gradually or suddenly (as it can during high flow or mudslides), sedimentation from erosion is an especially serious threat to aquatic life because it destroys essential breeding habitat for many benthic organisms and fish. Sources of erosion are abandoned roads, poorly-built logging and drilling-well access roads, logging and forestry practices, and agricultural activity (Fig. 8).

Effects of Stream Flow

Seasonal variation in flow has several effects. High flow presents a safety hazard to rafters and canoeists, especially those who are unfamiliar with the river and who do not know the limits of their technical skills. As mentioned above, high flow exacerbates certain pollution problems by transporting large amounts of trash and other pollutants from outside areas into BISO and by carrying increased amounts of sediment (Fig. 9). Flooding destroys trails and structures built along the river. During late summer, low flows produce a different set of problems by concentrating water pollutants. In these ways, the hydrology of the watershed directly influences the effects of other polluting activities.

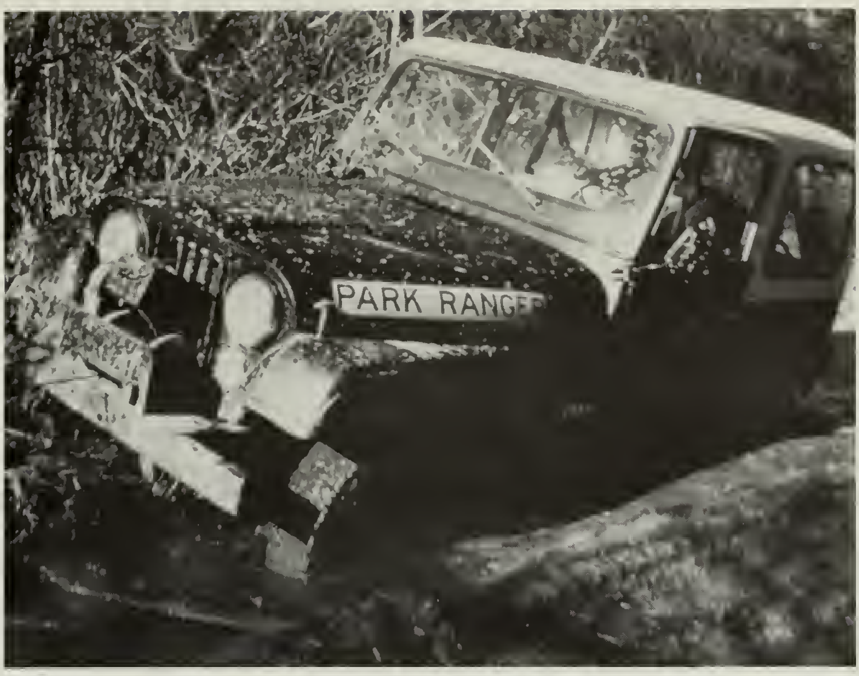


Figure 8. An NPS jeep is mired in mud on an unmaintained dirt road.

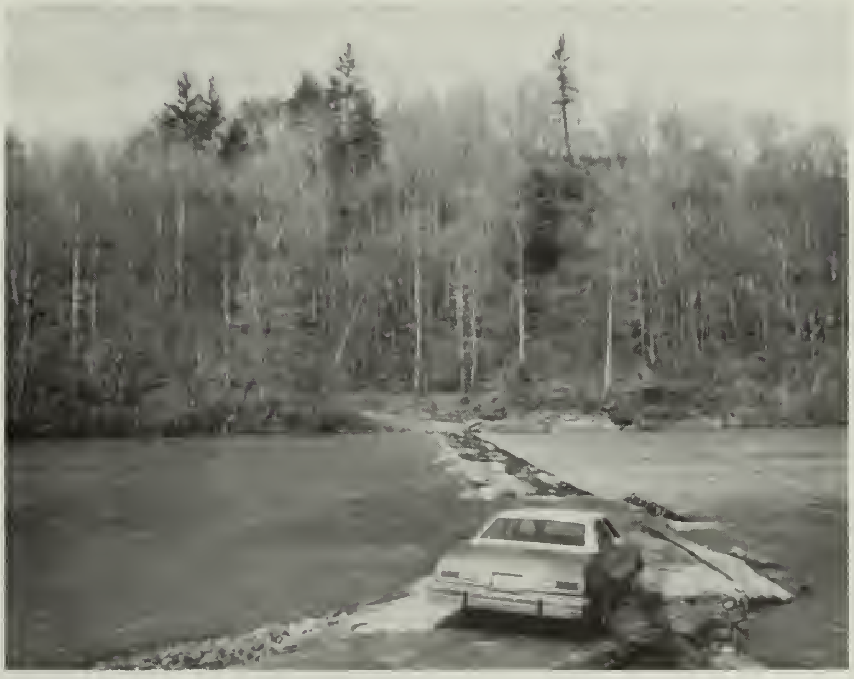


Figure 9. Leatherwood Ford at flood stage on the Big South Fork of the Cumberland River.

THE MONITORING PROGRAM

In order to determine the current status of BISO waters, and with future management practices in mind, the objectives of the water quality monitoring program were as follows:

1) collect background water quality data for streams in BISO;
2) identify areas of existing and potential water quality problems;
3) monitor changes in water quality over time;
4) provide data for effective natural resource management and for the determination of future needs;
5) provide data to help maintain water quality for visitor protection; and
6) provide data to help protect the aesthetic, ecological, and recreational values of the area.

Sampling Site Selection

The selection of water sampling sites was based, in part, upon the earlier study conducted by O'Bara et al. (1982), which identified the major areas and types of water quality impacts in the BISO area.

Two sampling sites were established on each of 16 major tributaries, with one site established at the mouth of each stream and the other site near the BISO boundary or in the headwaters of the stream (Fig. 1). In this way, water quality could be monitored as it entered the recreation area and again as it entered the main river. A comparison of data from two sites on the same stream would indicate whether the stream water improves or degrades in quality as it flows through BISO. Clear Fork, the largest of these tributaries within the boundaries of BISO, contains two additional sites. Sampling sites were assigned a two-letter code (based on an abbreviation of the stream name) followed by a number indicating the location of the site on the stream (Table 2).

Sampling Schedule

All sites except those on No Business Creek were designed for monthly sampling; No Business Creek was monitored semiannually because access is difficult and because it is free of impacts affecting other streams in the BISO area. Because of rugged terrain, poor weather, and other uncontrollable factors which at times blocked access to a site, some sites were not sampled every month. The sampling network was modified somewhat at the end of the first year, after initial experiences and data observations indicated where modifications were warranted (Table 3). These modifications are further explained in the discussions of each stream that occur later in this report.

Table 2. Two-letter codes for stream sampling sites.

BN	Bandy Creek
BR	Bear Creek
CL	Clear Fork
DF	Difficulty Creek[1]
GR	Grassy Fork of Williams Creek
LN	Laurel Fork of North White Oak Creek
LS	Laurel Fork of Station Camp Creek
MC	Mill Creek on North White Oak Creek[1]
NB	No Business Creek
NR	New River
NW	North White Oak Creek
PI	Pine Creek
PA	Parch Corn Creek[1]
PU	Puncheoncamp Fork of Williams Creek
RO	Rock Creek
RP	Roaring Paunch Creek
SC	Station Camp Creek
TR	Troublesome Creek[1]
WL	Williams Creek
WO	White Oak Creek

[1] Recommended future monitoring sites.

Table 3. Modifications in sampling sites and frequency of sample collection.

First Year's Schedules	Modification After First Year
Sampling at BN-1 and BN-3	Substituted BN-2
Sampling at SC-1	Substituted SC-2
Sampling at WL-1	Substituted WL-2
Site WO-2	Eliminated
Monthly sampling CL-1	Changed to every two months
Monthly sampling NR-1	Changed to every two months
Monthly sampling NW-1	Changed to every two months
Monthly sampling LN-1	Changed to every two months
Monthly sampling SC-2	Changed to every two months
Monthly sampling LS-1	Changed to every two months
Monthly sampling BR-3	Changed to every two months

METHODS USED AND PARAMETERS SELECTED

Methods

The water quality parameters to be measured were selected on the basis of expected water quality problems and on the manpower and funding capacity of the water quality laboratory at BISO. Fifteen water quality parameters were selected as the minimum necessary to identify water quality concerns and to meet the water monitoring objectives described earlier. Table 4 summarizes these fifteen parameters and the methods of analysis used for each. Natural levels in BISO for 11 of the parameters are listed in Table 5.

Temperature, pH, conductivity, and dissolved oxygen were determined in the field; all other parameters were determined in the laboratory at BISO. Water samples were collected in polypropylene bottles or sterilized Whirl-Pak bags (for bacteria samples) and transported on ice to the laboratory for analysis. Water samples were generally collected below the mixing zone of stream riffles. All field instruments were cleaned and checked for proper operation on a routine basis. The Hach Digital Titrator used for laboratory analyses was periodically checked using a buret and standard methods.

Water Quality Parameters

Temperature. Temperature is a water quality parameter that directly affects aquatic life, especially since oxygen becomes less soluble in water as water temperature increases. Increased temperatures accelerate the biodegradation of organic material both in the overlying water and in bottom deposits, thus increasing demands on the oxygen resources of a given system. These increased demands can lead to total

Table 4. Field and laboratory procedures used for analysis of the 15 water quality parameters used in the study.

Water Quality Parameter	Method of Analysis
Temperature and dissolved oxygen	YSI Model 58 dissolved oxygen-temperature meter (field analysis)
pH	Orion Model 399A/F pH meter with combination electrode (field analysis)
Conductivity	Beckman Model RB-5 and RB-6 conductivity meter (field analysis)
Alkalinity	Hach digital titrator using sulfuric acid and bromcresol green-methyl red indicator (laboratory analysis)
Acidity	Hach digital titrator using sodium hydroxide and phenolphthalein indicator (laboratory analysis)
Hardness	Hach digital titrator using EDTA tetrasodium salt and "ManVer" hardness indicator (laboratory analysis)
Chloride	Hach digital titrator using mercuric nitrate and diphenylcarbazone indicator (laboratory analysis)
Iron, sulfate, and manganese	Bausch & Lomb Spectronic 20 using Bausch & Lomb "Spectrokits" (laboratory analysis)
Turbidity	Hach Model 2100 turbidimeter (laboratory analysis)
Total coliform, fecal coliform, and fecal streptococcus	Membrane filtration using ENDO, MF-C, and azid media (laboratory analysis)

oxygen depletion and noxious septic conditions. Temperature also affects the decomposition process by which water purifies itself, and therefore the aesthetic and sanitary qualities that exist. Further, each aquatic species has a different temperature tolerance. Smallmouth bass, for example, can temporarily tolerate up to about 29°C (84°F) but brook

Table 5. Water quality conditions typically observed in natural, unpolluted streams in the BISO area. (Based on data from O'Bara et al. [1982] and from the present study.)

Parameter	Typical Levels
Temperature	0 to 25°C (32 to 77°F), common range
pH	6.0 to 7.5 (may be less in sandstone areas)
Conductivity	$\leq$ 60 µmhos/cm in limestone-influenced waters $\leq$ 30 µmhos/cm in waters unaffected by limestone
Dissolved Oxygen	$\geq$ 5.0 mg/L (suitable for aquatic life)
Alkalinity	$\geq$ Acidity (in general) $\leq$ 5 mg/L in waters unaffected by limestone
Hardness	$\leq$ 30 mg/L in limestone-influenced waters $\leq$ 20 mg/L in waters unaffected by limestone
Chloride	$\leq$ 5.0 mg/L
Iron	$\leq$ 0.2 mg/L
Manganese	$\leq$ 0.5 mg/L
Sulfate	$\leq$ 10 mg/L
Turbidity	$\leq$ 10 NTU
Fecal Coliform	< 100 colonies/100 ml

trout only to about 19°C (66°F) (EPA 1976). In BISO, temperatures of natural, unpolluted streams typically range from 0°C (32°F) to about 25°C (77°F).

Hydrogen Ion Activity (pH). A pH measurement quantifies the hydrogen ion activity in a water sample. It is mathematically related to hydrogen ion activity according to the expression: $pH = -\log_{10}(H^+)$, where (H^+) is the hydrogen ion activity. Measurement of pH is based on a scale of 0 to 14 where 7 is neutral, less than 7 is acidic, and greater than 7 is alkaline. Because pH is a logarithmic function, a change from pH 7.0 to pH 6.0 is a ten-fold increase in acidity, and a change from pH 7.0 to pH 5.0 is a 100-fold increase in acidity. The pH for naturally occurring unpolluted waters within BISO normally ranges from 6.0-8.5, with a few streams having a pH of less than 6.0 because of naturally acidic conditions related to the sandstone geology of the area.

In BISO, pH is affected by the presence of acid mine drainage, which is formed through a complex series of chemical reactions. During the course of mining activities, pyrite (ferrous sulfate) is exposed to air and oxidizes to ferric sulfate. Hydrolysis of the ferric sulfate leads to the formation of ferric hydroxide ($FeOH_3$) and sulfuric acid (H_2SO_4). Further reactions result in a mixture of sulfuric acid, iron compounds, acid salts, and other elements. This mixture is known as acid mine drainage. As this solution enters a stream it lowers the stream's pH and reduces alkalinity, producing sterile conditions that adversely affect aquatic life. Soft water systems, such as those in BISO that have low buffering capacity, are particularly susceptible to these chemical changes caused by acid mine drainage. Neutralization of acid mine water causes the metallic ions in solution (ferric hydroxide and hydroxide sulfates) to precipitate out into the stream bottom. The ferric hydroxide precipitate is yellowish-orange in color and is commonly referred to as "yellow-boy." It is this precipitate that causes discoloration of affected waters (Brazinski 1979). In general, a pH range of 6.5-9.0, with no change greater than 0.5 unit outside the natural seasonal maximum or minimum, is protective of fresh-water aquatic life and is considered harmless to fish (EPA 1976; AFS 1979).

Specific Electrical Conductance. Specific electrical conductance, or conductivity, is a measure of the capacity of water to convey an electrical current. It is an indication of the concentrations of ionized substances, which constitute much of the total dissolved solids in streams in BISO. As such, conductivity is a good indicator of a variety of impacts on water quality in BISO. Clean streams within BISO have a conductivity of 60 μmhos/cm or less in watersheds with limestone, or 30 μmhos/cm or less in watersheds without limestone. Conductivity levels above 60 μmhos in BISO streams indicate pollution.

Dissolved Oxygen. Dissolved oxygen historically has been a constituent of major interest in water quality investigations. It is generally considered to be significant in the protection of aesthetic qualities of water as well as in the maintenance of fish populations and other aquatic life. For this reason, dissolved oxygen concentrations are an important gauge of existing water quality and the ability of a water body to support a well-balanced aquatic environment. A minimum level of 5.0 mg/L is normally needed to support fish life (EPA 1976), and this level or higher is typical of undisturbed streams in BISO.

Alkalinity. Alkalinity is the sum total of components in the water that tend to elevate the pH of the water above a value of about 4.5, normally expressed in equivalents of calcium calbonate ($CaCO_3$). Examples of commonly occurring constituents of natural waters that increase the alkalinity are carbonates, bicarbonates, phosphates, and hydroxides. Alkalinity is a measure of the buffering capacity of the water or the water's ability to buffer against acids and avoid depressed pH levels. Since pH has a direct effect on organisms and influences the toxicity of certain pollutants in the water, the buffering capacity is important. Because of sandstone bedrock, waters of BISO are low in alkalinity ($\leq$10 mg/L) unless limestone effects occur. The minimum alkalinity recommended for fish and wildlife is 20 mg/L as $CaCO_3$ (NAS 1973). This criterion assumes natural alkalinity is not changed by more than 25 percent (AFS 1979).

Acidity. An expression of a water's capacity to donate hydrogen ions, acidity is the strength of the acids in water or the water's corrosiveness. Acidity is also reported as equivalents of $CaCO_3$. The acidity of natural waters is normally very low. Natural waters of BISO should have an acidity value approximately equal to or less than that of alkalinity. If acidity greatly exceeds the value of alkalinity, it generally is an indication of acid mine drainage.

Hardness. Water hardness is a measure of the polyvalent metallic and alkaline earth ions dissolved in water. In fresh waters these are principally calcium and magnesium (divalent), although other metals such as iron, strontium, and manganese may contribute. Like alkalinity and acidity, hardness also is reported as equivalents of $CaCO_3$ (EPA 1976). Natural waters in BISO generally have a hardness of 30 mg/L or less if affected by limestone or a hardness of 15 mg/L or less if not affected by limestone.

Chloride. Chloride is an ion derived from natural geologic formations, but it also can be associated with sewage treatment, the use of road salt, or brine water from drilling activities. Thus, elevated chloride levels can indicate pollution from these sources. Chloride levels of undisturbed natural waters in BISO are normally below 5 mg/L.

Iron and Manganese. Natural waters contain variable but minor amounts of iron. Manganese is found in various salts and minerals, frequently in association with iron compounds, but does not occur naturally as a metal. As the principal metals associated with acid mine drainage, iron and manganese serve as indicators of mining impacts on water. In natural waters in BISO, iron and manganese levels are generally less than 0.2 mg/L and 0.5 mg/L, respectively, although iron levels may rise above 0.2 mg/L from erosion of disturbed soil. To protect aquatic life, the iron concentration in fresh water should not exceed 1.0 mg/L (EPA 1976). A criterion for manganese has not been established for fresh-water aquatic life.

Sulfate. Sulfate is widely distributed in nature and may be present in natural waters in concentrations ranging from a few to several thousand milligrams per liter. Mine drainage wastes may contribute large amounts of sulfate through pyrite oxidation. Undisturbed natural waters in BISO normally have sulfate levels below 10 mg/L.

Turbidity. The turbidity test measures in a water sample the optical property that results from the scattering and absorption of light by the particulate matter present. The amount of turbidity registered is dependent on such variables as number, size, shape, and refractive indices of the particles. Turbidity occurs in most surface waters as a result of suspended clay, silt, finely divided organic and inorganic matter, plankton, and other microorganisms. No universal agreement exists regarding allowable levels of turbidity (AFS 1979). In BISO's waters, turbidity is generally 10 NTU or less.

Bacteria. Bacterial analyses are used as an indication of sewage impacts. Total coliform bacteria are an index of levels of enteric organisms present in water but include certain nonenteric organisms as well. Fecal coliforms and fecal streptococci normally occur in the fecal waste of humans and other warm-blooded animals. A fecal coliform/ fecal streptococcus ratio has been developed in order to provide another measure to help determine if surface water contamination is more likely to be of human or animal origin. Generally a ratio equal to or greater than 4.0 is indicative of human contamination, and a ratio less than about 0.7 is indicative of animal pollution. Intermediate ratios are nondeterminant but probably imply wastes from both human and animal sources. These ratios are not precise but are generally useful for up to 24 hours after the contamination occurs, especially for samples gathered near a pollution source and for samples where fecal coliform concentrations are above a level of 100 colonies per 100 ml. After 24 hours, or for long distances below pollution sources, differential die-off rates alter the ratio and it is not reliable (Oleckno 1982). In undisturbed waters of BISO fecal coliform is generally below 100 colonies/100 ml.

CATEGORIES OF STREAMS

The Five Categories

Water quality and pollution problems in the Big South Fork NRRA are delineated by the data collected during the two-year monitoring period and reported here. For the sake of discussion, stream reaches associated with the sampling sites have been grouped into five major water quality categories, based on 1983-84 data, as follows:

1. clean/sandstone-influenced
2. clean/limestone-influenced
3. slightly polluted
4. moderately polluted
5. severely polluted

Table 6 shows the parameter concentration levels used in delineating the five categories. The categories are based primarily on the findings of O'Bara et al. (1982), who observed natural background levels of chemical constituents in streams of the Big South Fork area. In addition to the O'Bara observations, our own field knowledge of the streams (such as observations of mining activity or the presence of sewage outflow pipes), was used to segregate the five categories (Fig. 10). In some cases, only a few parameters in a particular stream reach may have exceeded normal levels, but done so to a high degree. Consequently, if data showed certain parameters in a stream to be extraordinarily high or low in value, that stream was then classified as "polluted," without all of the parameters necessarily being unnaturally high or low in concentration. In this way, the parameter values served as general guidelines for categorizing the streams.

Table 6. Concentration levels of parameters used for determining water quality categories.[1]

Criterion	Clean/ Sandstone-influenced	Clean/ Limestone-influenced	Slightly Polluted	Moderately Polluted	Severely Polluted
Specific Conductivity (µmhos/cm)	≤30	≤60	>30	>100	>150
pH (units)	5.5-7.0	6.0-7.5	6.0-7.5	6.0-7.5	<5.0 in extreme cases
Chlorides (Cl)(mg/L)	≤5.0	≤5.0	≤5.0	>5.0	>5.0
Iron (mg/L)	≤0.2	≤0.2	≤0.2	most <0.2	most >0.2
Manganese (mg/L)	≤0.5	≤0.5	≤0.5	most <0.5	most >0.5
Sulfates (SO_4) (mg/L)	≤10	≤10	≤10	>20	most >50
Alkalinity (mg/L)	<5.0	most >10	>10	most >20	most <20; extreme cases <2.5
Bacteria[2] (colonies /100 ml)	most FC near zero; low TC	most FC near zero; low TC	if sewage, few FC > 100	if sewage, most FC > 100	if sewage most FC > 100
Hardness (mg/L)	<20	>20	>20	most >60	few >100
Turbidity (units NTU)	<10	<10	<10	few >10	few >10

[1] "Most" means ≥75% of the samples have the indicated readings; "few" means ≤25% of the samples have the indicated reading.

[2] FC = fecal coliform concentrations; TC = total coliform concentrations.

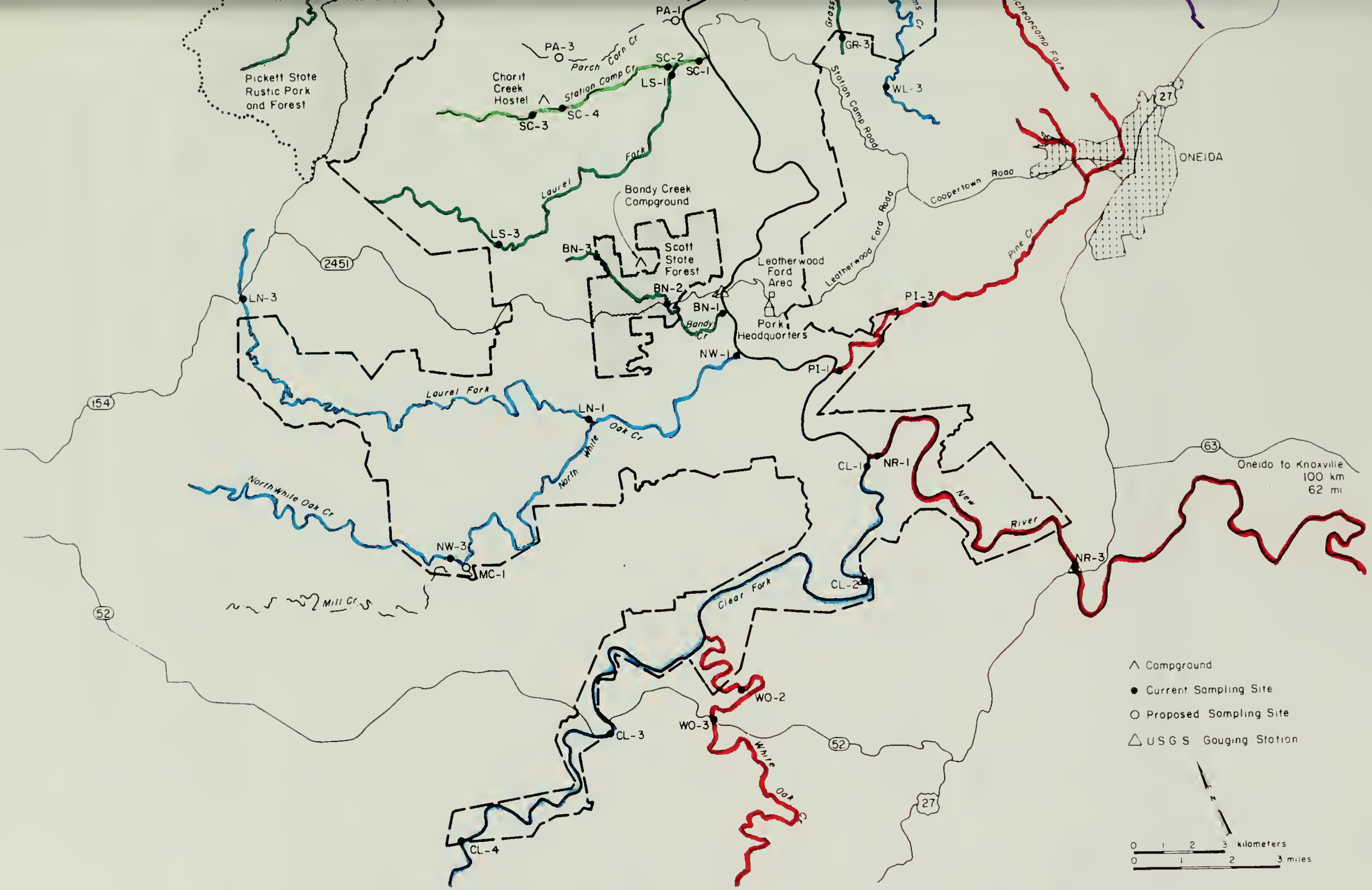
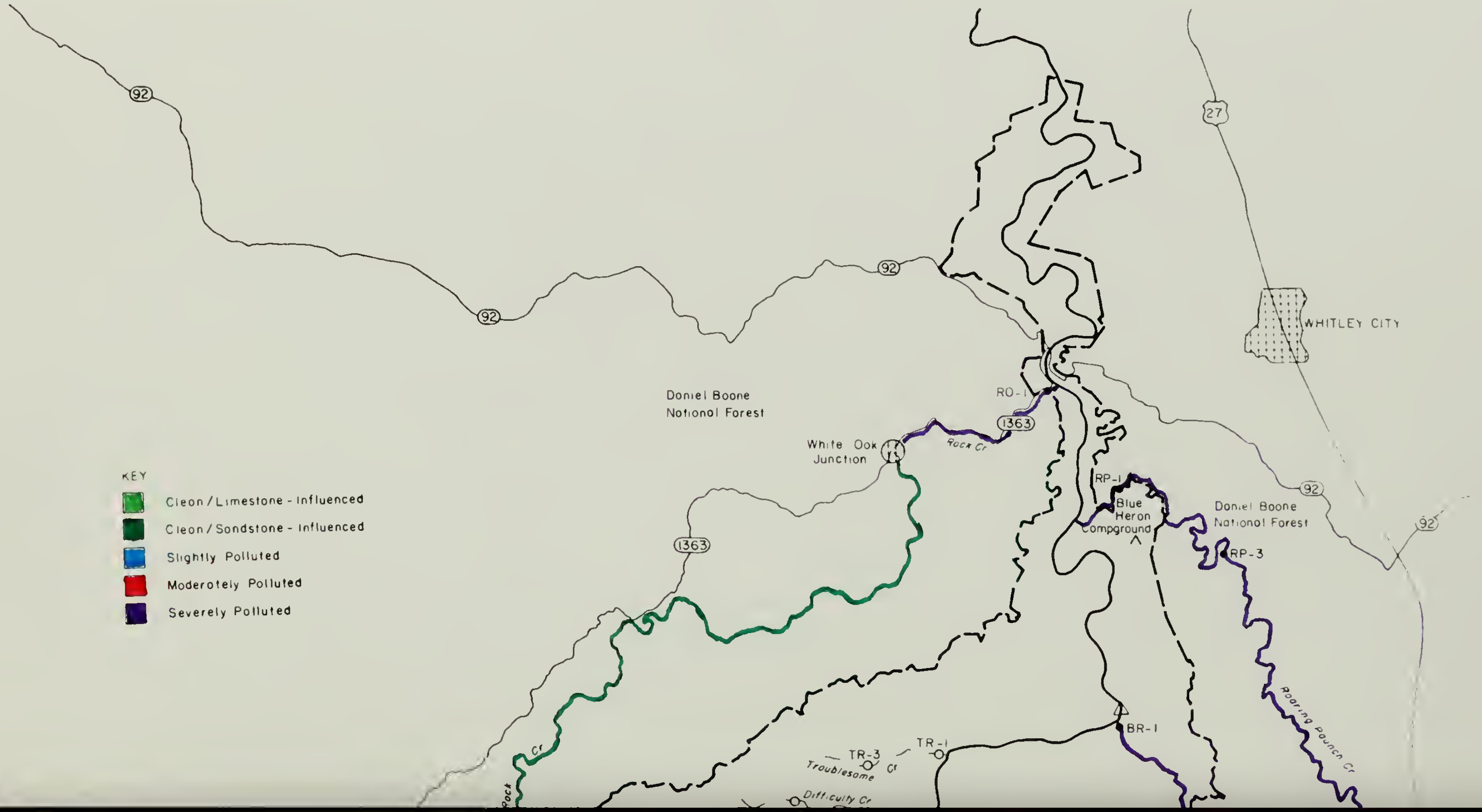


Figure 10. Stream category designations for tributaries monitored in the Big South Fork National River and Recreation Area.


KEY
🟩 Cleon / Limestone - Influenced
🟩 Cleon / Sondstone - Influenced
🟦 Slightly Polluted
🟥 Moderotely Polluted
🟪 Severely Polluted
92
92
92
92
92
27
1363
1363
Doniel Boone Notionol Forest
White Ook Junction
Rock Cr
RO-1
RP-1
Blue Heron Compground
RP-3
Doniel Boone Notionol Forest
WHITLEY CITY
Roaring Pounch Cr
BR-1
TR-3
TR-1
Troublesome Cr
Difficulty Cr
Rock Cr

It should be remembered that the categories are for the sake of discussion and are not official stream classifications. The State of Tennessee has established water quality criteria (Appendix F) for natural streams and provides stream classifications relating to recreational use. However, the criteria and classifications are very general and not always applicable. In particular, some criteria are ill-suited for evaluating headwater streams. For example, the state mandates that pH is not to fall below 6.5 for the protection of fish and aquatic life. Such a limit is unrealistic for headwater streams in Appalachia, where natural pH levels are often below 6.5, especially in unbuffered, sandstone-based streams (Helvey and Kunkle, 1986). This situation is also found in BISO waters. Because of such discrepancies between state criteria and naturally occurring conditions in BISO, State of Tennessee criteria were not used for site comparisons in this study or for development of the categories described above.

The first water quality category, "clean/sandstone-influenced," comprises unpolluted streams flowing primarily through sandstone topography. These streams have little contact with limestone and therefore are poorly buffered, as reflected by their low natural alkalinity.

The second water quality category, "clean/limestone-influenced," includes unpolluted streams flowing through limestone-influenced watersheds where calcium buffering occurs and is reflected by higher alkalinity, hardness, and pH values in the water samples.

The third, fourth, and fifth categories above are for streams that exhibit impacts of land and resource use on water quality, such as coal mining, oil and gas extraction, forestry practices, agricultural practices, and municipal or household sewage discharges. Stream reaches where water quality is affected by one or more of these polluting activities were categorized as slightly, moderately, or severely polluted, according to the degree of impact as indicated by our data and field observations (Table 7).

Water Quality Comparisons

The five stream types differ noticeably in their respective levels of alkalinity, conductivity, pH, and hardness. Data on these four water quality parameters are compared in Figs. 11-14 for five stream sites characteristic of the five categories. Clean/limestone-influenced (buffered) streams (Station Camp Creek [SC] in the examples) show generally higher levels of alkalinity and pH. Conductivity and hardness are relatively higher in the polluted streams (New River [NR], Clear Fork [CL], and Bear Creek [BR]). Clean/sandstone-influenced streams

Table 7. Activities suspected to be influencing the water quality of polluted streams in BISO.

Streams (by category)	Coal mining	Oil and gas exploration	Agriculture and forestry	Sewage discharge
Slightly Polluted Streams				
Clear Fork	X	X	X	
Laurel Fork of North White Oak Creek			X	X
North White Oak Creek	X	X	X	
Williams Creek	X		X	
Moderately Polluted Streams				
New River	X	X		
Pine Creek		X		X
Puncheoncamp Fork of Williams Creek	X	X		
White Oak Creek	X	X	X	
Severely Polluted Streams				
Bear Creek	X			
Roaring Paunch Creek	X	X		X
Lower Rock Creek	X			

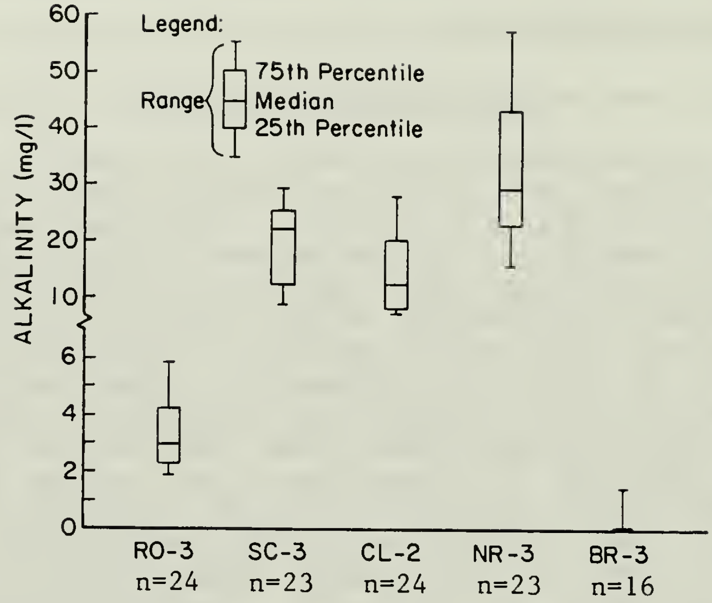


Figure 11. Medians and ranges of alkalinity values for the five example stream sites.

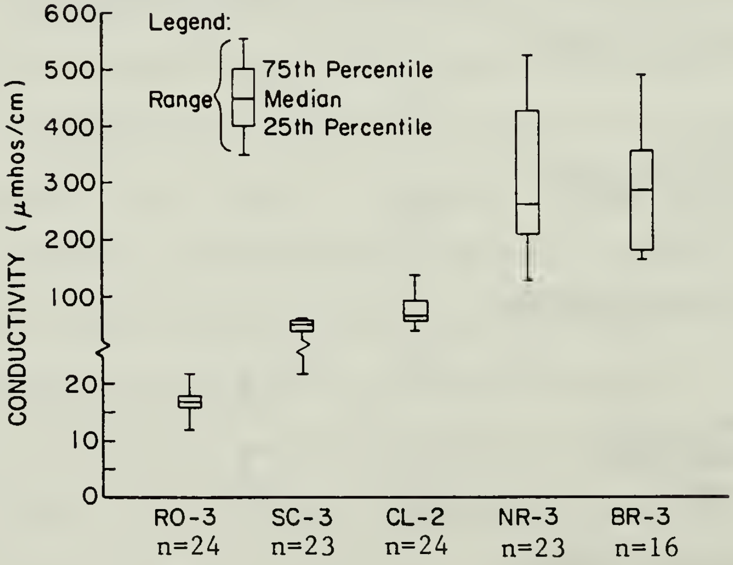


Figure 12. Medians and ranges of conductivity values for the five example stream sites.

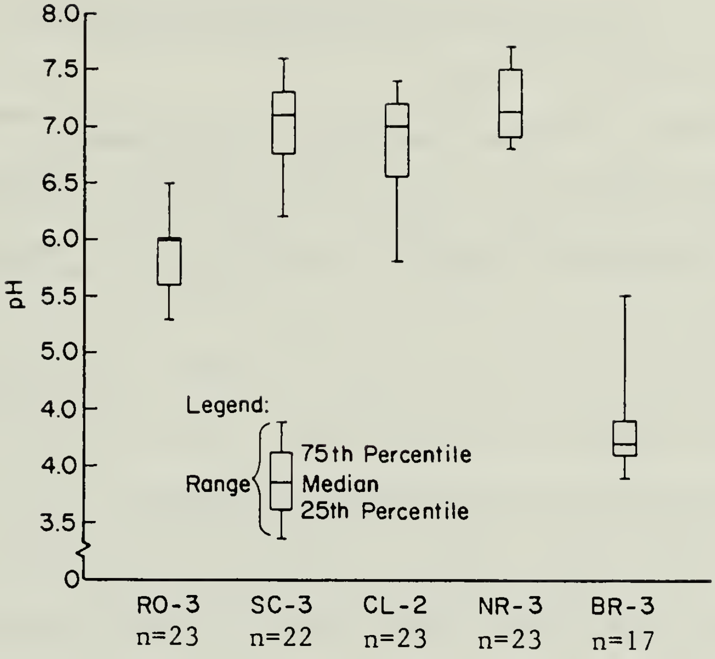


Figure 13. Medians and ranges of pH values for the five example stream sites.

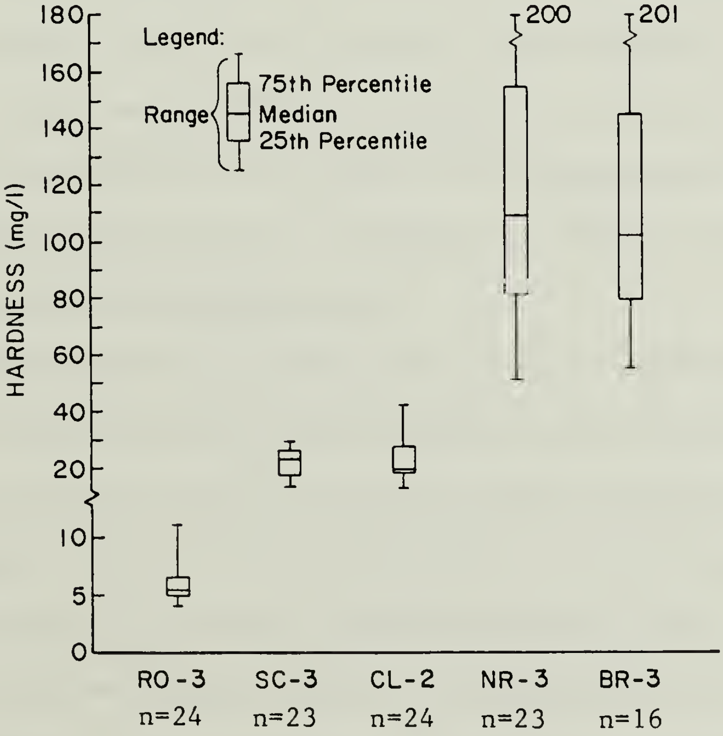


Figure 14. Medians and ranges of hardness values for the five example stream sites.

(Rock Creek [RO]) are low in all constituents. These examples illustrate the way in which comparison of various water quality constituents allows categorization of a stream.

In the following sections, each stream or stream segment is discussed within its category relative to the influences affecting it and the concomitant impacts on water quality, as these are reflected in the data.

THE STREAMS

Clean/Sandstone-Influenced Streams

The streams described in this section are not polluted to any significant degree. However, they are all particularly susceptible to acid contamination since they are poorly buffered and have very low alkalinity.

Bandy Creek (BN). Much of Bandy Creek flows through Scott State Forest within BISO (Fig. 10). Bandy Creek is a stream of extremely good water quality but is affected by sedimentation from past logging practices. Conductivity and hardness levels are very low (mostly 10-20 µmhos/cm and <10 mg/L, respectively), indicating a stream of good water quality with little evident effect from limestone. However, Bandy Creek appears to be affected by ongoing construction of a large campground complex above site BN-2. Elevated iron concentrations (between 0.30 and 0.65 mg/L) were noted in July through October 1984 at site BN-2. The erosion and runoff of disturbed soil during construction could explain the changes in iron levels. The campground will contain a sewage treatment plant that will discharge into Bandy Creek, just above BN-2, once the campground is operating.

Bandy Creek originally (in 1983) contained two sampling sites, BN-1 and BN-3, but these two sites were eliminated after one year of sampling. In their place, site BN-2 was established in 1984, just below the future discharge point of the treatment plant, so that background data could be collected prior to plant operation. During 1984 at BN-2, 9 out of 10 fecal coliform bacteria samples had concentrations of less than 100 colonies/100 ml, which classifies the stream as suitably clean for swimming by EPA (1976) and State of Tennessee (Appendix F) criteria.

Grassy Fork of Williams Creek (GR). Grassy Fork is a small stream of excellent water quality in the eastern portion of BISO (Fig. 10). One or two farms along this stream exert the only possible impact on its water quality. The conductivity of the stream is almost consistently below 20 µmhos/cm, indicating no adverse impacts or influence from limestone. Bacteria counts also are low, with fecal coliform (FC) below 100 colonies/100 ml in nearly all samples. The low levels of metals, chlorides, turbidity, hardness, and acidity all indicate water of good quality.

Laurel Fork of Station Camp Creek (LS). The water in this stream is also of especially good quality and appears to be unaffected by any impacts, although there is light agricultural activity on the watershed. The data show stable pH readings averaging 6.5, dissolved oxygen levels usually near saturation, and consistently low metals, chlorides and turbidities—all factors favorable to a healthy fish population. Alkalinity readings fall mostly in the 5.0-10.0 mg/L range, and this condition also is favorable to fish. In fact, reproducing brown and rainbow trout populations have been reported in this stream (O'Bara et al. 1982). Bacteria counts in 1983 and 1984 for both sites are low, with fecal coliforms almost always under 100 colonies/100 ml. In the future, however, water quality in Laurel Fork could be affected by the Bandy Creek Ranger Station complex, a deferred development project that will include sewage treatment facilities (i.e., septic tanks and disposal fields).

Rock Creek, Upper Reach (RO). The upper segment of Rock Creek, from Pickett State Rustic Park and Forest to White Oak Junction, is a clean/sandstone-influenced stream. In fact, the stretch from the

Kentucky-Tennessee line to White Oak Junction in Kentucky (about 20 km or 12 mi) is classified as a Kentucky Wild River. Site RO-3, inside Pickett State Park (Fig. 10), shows very low levels of conductivity ($\bar{x}$ = 17 μmhos/cm), turbidity ($\bar{x}$ = 1.5 NTU), hardness ($\bar{x}$ = 6.0 mg/L), and acidity ($\bar{x}$ = 6.2 mg/L). Fecal coliform counts generally remained low (0-20 colonies/100 ml) with two exceptions. In August 1983, fecal coliforms registered 281 colonies/100 ml, and in August of 1984 the count was 190 colonies/100 ml. The pH levels are fairly stable and average about pH 6.0.

Clean/Limestone-Influenced Streams

These two streams, like the four just discussed, exhibit no adverse impacts whatsoever. However, they are highly buffered by limestone and as such are characterized by relatively higher alkalinity levels.

No Business Creek (NB). No Business Creek drains a heavily forested watershed that exhibits no significant water quality impacts. Sampling for this stream was originally scheduled at six-month intervals because access is particularly difficult. However, the stream was sampled twice during the summer months when access was easier. Sample analysis showed No Business Creek to be a stream of very good water quality, with conductivity ranging from 27 to 48 μmhos/cm. The pH levels are consistently near neutral, ranging from pH 6.8 to 7.5, and dissolved oxygen readings were high for all samples ($\bar{x}$ = 10.2 mg/L). Alkalinity averaged 14.0 mg/L at NB-1 and 11.8 at NB-3, indicating the influence of limestone. Turbidity averaged 2.0 and 1.8 NTU at the two sites, and metal concentrations were always at very low levels.

Station Camp Creek (SC). Station Camp Creek is an almost totally forested watershed in the heart of BISO receiving no significant impacts on its water quality (Fig. 10). Limestone outcrops in the headwaters of the stream are indicated in the data by the slightly elevated conductivity, alkalinity, and hardness levels at site SC-3, with conductivity often over 50 µmhos/cm and alkalinity and hardness often exceeding 25 mg/L. On the other hand, a comparison of sites SC-1 and SC-2 showed a difference in conductivity and hardness levels, suggesting that Laurel Fork of Station Camp Creek was not being affected by limestone to the same degree as Station Camp Creek. Average conductivity and hardness levels for site SC-1 were 32 µmhos/cm and 12.4 mg/L, respectively, compared to 51 µmhos/cm and 20.9 mg/L for site SC-2.

Presently, Charit Creek Hostel is the only apparent threat to the water quality of Station Camp Creek. In its present condition, the hostel is a backcountry camp area that is receiving increasingly heavy use. As many as 30 horses and riders and additional backpackers have been reported using the area simultaneously during a weekend. Site SC-3 is located upstream of Charit Creek Hostel. Site SC-4, an additional site for monitoring bacteria only, was established downstream of the hostel so that any bacteriological impacts on the stream could be monitored. A comparison of the 1984 bacteria data for the two sites, however, did not show any impact from hostel use. Site SC-1, on Station Camp Creek below the confluence with Laurel Fork, was eliminated after one year's data was collected; site SC-2 was established above Laurel Fork so that the impacts on Station Camp Creek alone could be monitored without the influence of Laurel Fork waters.

Slightly Polluted Streams

The four streams in this category are of generally good quality but cannot be considered "clean," as they exhibit detectable impacts from one or several polluting activities, described below.

Clear Fork (CL). Clear Fork is the major tributary at the southern tip of the Big South Fork NRRA boundary. Water was monitored at four sampling sites over approximately a 32 km (20 mi) stretch. Clear Fork is potentially affected by agricultural practices, mining, and oil and gas exploration, all of which are occurring in the watershed. Moderate levels of conductivity and hardness and slightly elevated levels of sulfate (ranging from under 10 to 23 mg/L) can be found throughout the drainage. Conductivity increases as the stream flows through BISO, varying from a mean of 57 µmhos/cm at site CL-4 to a mean of 87 µmhos/cm at site CL-1, which suggests continuous impacts to the stream along its main stem. Some contamination is due to polluted water flowing in from White Oak Creek, which joins with Clear Fork between sites CL-2 and CL-3. (Water quality data collected by BISO and by the U.S. Geological Survey for Clear Fork at site CL-2 are provided in Appendix E.)

Laurel Fork of North White Oak Creek (LN). Water in this stream in the southwest part of BISO is generally clean. The major potential effects are agricultural and domestic runoff, erosion from roads, and periodic sewage discharge from a small campground located upstream of Route 154, which crosses the headwaters of Laurel Fork. At present, this little-used campground is having no major impact on the stream as corroborated by low fecal coliform counts: all samples but one were below 200 colonies/100 ml. However, the potential for more severe impact will develop if the campground eventually becomes heavily used.

Conductivity levels decrease from a mean of 44 μmhos/cm at the upper site to a mean of 21 μmhos/cm at the lower site, suggesting that as the stream accumulates additional dilution water, concentrations of pollutants are lowered.

Laurel Fork has supported a reproducing population of brown trout. Personal contacts by the senior author with visitors suggest that trout still exist in the stream, although sediment from the recent bridge construction on Highway 154 at Laurel Fork has had a severe impact (field observation). The particular effects of sediment on the trout have not been determined.

North White Oak Creek (NW). North White Oak Creek in the southwestern corner of BISO (Fig. 10), though essentially a clean stream, is being affected slightly by agricultural practices in its watershed. This is seen in conductivity values averaging 38 μmhos/cm and peaking at 59 μmhos/cm at site NW-3. Mill Creek, which drains into North White Oak Creek, periodically has had very turbid water which suggests sedimentation problems; therefore, monitoring of Mill Creek is advised. This sediment problem possibly is related to current oil and gas activities.

Williams Creek (WL). Williams Creek, near Oneida, is one of only two reasonably clean streams in the east-central portion of BISO (the other is Grassy Fork of Williams Creek) (Fig. 10). The stream is stocked regularly with rainbow trout by the Tennessee Wildlife Resources Agency and is believed to have a reproducing population. However, it experiences slightly elevated conductivity ($\bar{x}$ = 31 μmhos/cm) and hardness ($\bar{x}$ = 12.8 mg/L) levels at site WL-1. According to field observations, the major impact on Williams Creek is sedimentation from unimproved roads; however, one surface mine is known to exist in the southwest portion of the watershed. The upper site, WL-3, had a mean conductivity reading of 39 µmhos/cm with a maximum reading of 62 µmhos/cm, which tends to support those observations. The lower sampling site on Williams Creek, site WC-1, appeared to be influenced by Puncheoncamp Fork waters. In order to monitor the water quality of Williams Creek alone, a new site, WC-2, was established on Williams Creek just above its confluence with Puncheoncamp Fork, and site WC-1 was eliminated.

Moderately Polluted Streams

Polluting activities common in the BISO watershed exert a very apparent impact upon the water quality of these four streams. These impacts are beginning to adversely influence recreational and aesthetic values as well as aquatic life.

New River (NR). New River is a large drainage of approximately 615 km^2 (382 mi^2) that is affected by coal mining, oil and gas exploration, and agricultural and forestry practices, according to our data and field observations. Only in its last 13 km (8 mi) does New River flow into BISO before it joins with Clear Fork to form the Big South Fork of the Cumberland River (Fig. 10). This 13 km section of New River within BISO is a stream characterized by high conductivity, hardness, and sulfate levels, with median readings of 265 µmhos/cm, 116 mg/L, and 80 mg/L, respectively; it therefore is considered "moderately polluted." New River is affected by erosion resulting from extensive strip mining occurring in its headwaters. At extremely low flows, New River becomes very clear; however, high flows produce high turbidity levels and show a distinct difference at the confluence of New River and Clear Fork (Fig. 15). Even so, New River supports a variety of fish species (Brazinski 1979), and walleye have been caught in the spring during the spawning run. (Water quality data collected by BISO and by the U.S. Geological Survey for New River at site NR-3 are provided in Appendix E.)

Pine Creek (PI). Pine Creek is important in that it flows from Oneida directly to the Narrows and other parts of the main river popular with recreationists. Major activities affecting Pine Creek are channelizing of an upstream section and the discharge of sewage treatment plant wastes from Oneida, which result in a moderately polluted stream with a high sediment load and high bacteria counts. Surface mining and oil and

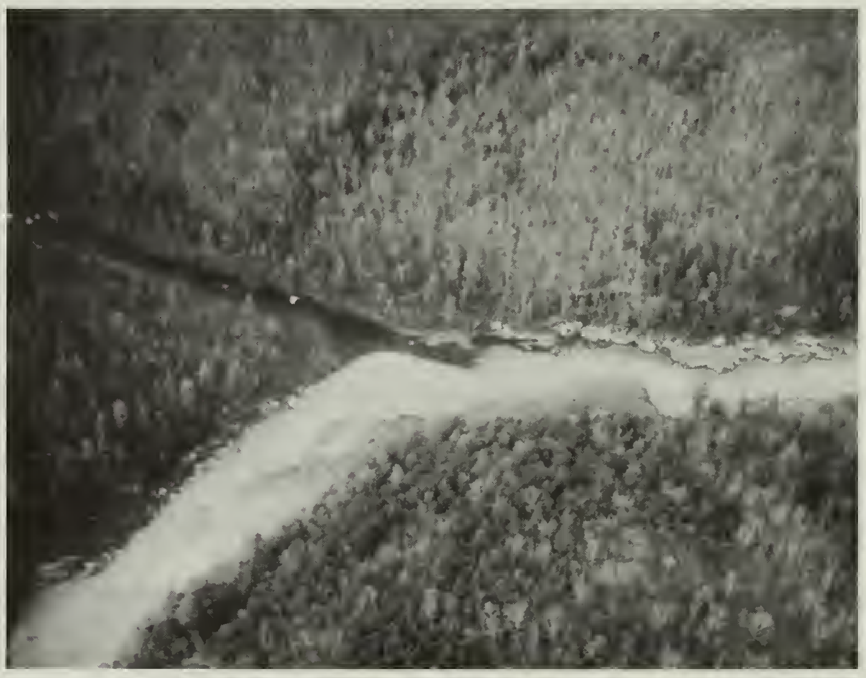


Figure 15. Confluence of Clear Fork (upper left) and New River (lower left), showing high turbidity levels in New River.

gas exploration also have an impact on Pine Creek. This stream experiences elevated levels of chloride (median = 7.5 mg/L), sulfate (median = 15 mg/L), conductivity (median = 141 μmhos/cm), and hardness (median = 53 mg/L) at site PI-3, which is closer to the pollution sources. Although water quality generally improves as the stream flows through BISO, the upper section is distinctly polluted: several samples taken at site PI-3 contained over 300 colonies of fecal coliforms per 100 ml.

Puncheoncamp Fork of Williams Creek (PU). This stream is moderately polluted by acid mine drainage from a few small abandoned strip mines, and it exhibits somewhat higher than natural levels of sulfate, with many values over 25 mg/L at PU-3. Since the sources of acid mine drainage are outside the boundary of BISO, water quality improves between the upper sampling site, PU-3, and the lower site, PU-1. Dilution effects from water entering the stream between the two sites may be a factor in diminishing stream degradation.

White Oak Creek (WO). Two streams named "White Oak Creek" occur in or near BISO. One lies in Kentucky outside the northern boundary of BISO; the other, in Tennessee, is a tributary of Clear Fork, which enters BISO at the southernmost boundary. The Tennessee stream is the one referred to in this report unless otherwise stated.

Most of White Oak Creek lies outside the BISO boundaries, and the stream is moderately affected by forestry practices and oil and gas exploration. These effects appear during low-flow periods, when this stream exhibits moderately high levels of sulfate (over 20 mg/L), conductivity (over 100 μmhos/cm), and hardness (over 25 mg/L). White Oak Creek originally contained two sampling sites, but because data from the two showed little difference over the course of a year, and because only a small section of the stream is in BISO, site WO-2 was eliminated.

Severely Polluted Streams

The three streams in this section are seriously degraded in quality. Acid mine drainage is the major source of contamination, resulting in elevated levels of metals and sulfates.

Bear Creek (BR). This stream is severely affected by acid mine drainage and is the most degraded of the 16 tributaries in this study. Abandoned surface mines are found throughout the headwater areas, making site BR-3 especially polluted. This site shows virtually no alkalinity, pH values of about 4.2, high acidity (often over 30 mg/L), high sulfate (most over 80 mg/L), and unnaturally high turbidity, manganese, iron, and hardness. A comparison of data at BR-1 and BR-3 shows that conductivity, hardness, and sulfate levels decrease and pH increases from the upstream sampling site to the downstream sampling site (Table 8). These data indicate that the water quality of Bear Creek improves as it flows through the recreation area, presumably due to the effects of self-purification and dilution as the water moves downstream from the sources of impact.

Aquatic life in Bear Creek is restricted to only a few tolerant benthic macroinvertebrate species. Aluminum was not among the indices used in this study because it is relatively difficult to measure; however, it is a constituent of acid mine drainage that is extremely toxic to aquatic life (O'Bara et al. 1982; Flora et al. 1984). Extensive reclamation is needed to restore Bear Creek to an ecologically sound and aesthetically acceptable stream.

Table 8. A comparison of values of seven water quality parameters at sites BR-3 and BR-1 in Bear Creek. Number of samples (n) are in parentheses.

Water Quality Parameter	BR-3 (upstream site)	BR-1 (downstream site)
pH[1]	4.3 (17)	5.1 (22)
conductivity (μmhos/cm)[1]	299 (16)	190 (21)
alkalinity (mg/L)[1]	0.2 (16)	2.3 (23)
acidity (mg/L)[1]	28.6 (16)	15.4 (23)
hardness (mg/L)[1]	115.1 (16)	73.1 (23)
iron (mg/L)[2]	0.26 (16)	<0.2 (23)
sulfate (mg/L)[2]	>80 (16)	66 (22)
manganese (mg/L)[2]	5.0 (15)	2.5 (19)

[1] mean value (for pH, calculated using H^+ concentrations)
[2] median value (median used where < or > values are found in data)

Roaring Paunch Creek (RP). This is a severely polluted stream that has been affected by acid mine drainage as well as agricultural and domestic runoff. Although Roaring Paunch Creek does not exhibit problems of low pH ($\bar{x} = 6.9$), elevated levels of other parameters such as conductivity, hardness, and sulfate (with medians of 144 μmhos/cm, 49.1 mg/L, and 44 mg/L, respectively) distinctly indicate the presence of acid mine drainage. In fact, many active and abandoned mines are located along the creek. High levels of iron (maximum 0.6 mg/L), manganese (maximum 1.3 mg/L), and chloride (maximum 321 mg/L) occurred during low-flow periods in August and September at the downstream site, RP-1. On three occasions, chloride levels of 700 mg/L or higher were recorded at this site. • It is uncertain whether the elevated chloride concentrations are natural or caused by outside influences such as coal mining or oil and gas exploration (Fig. 16).

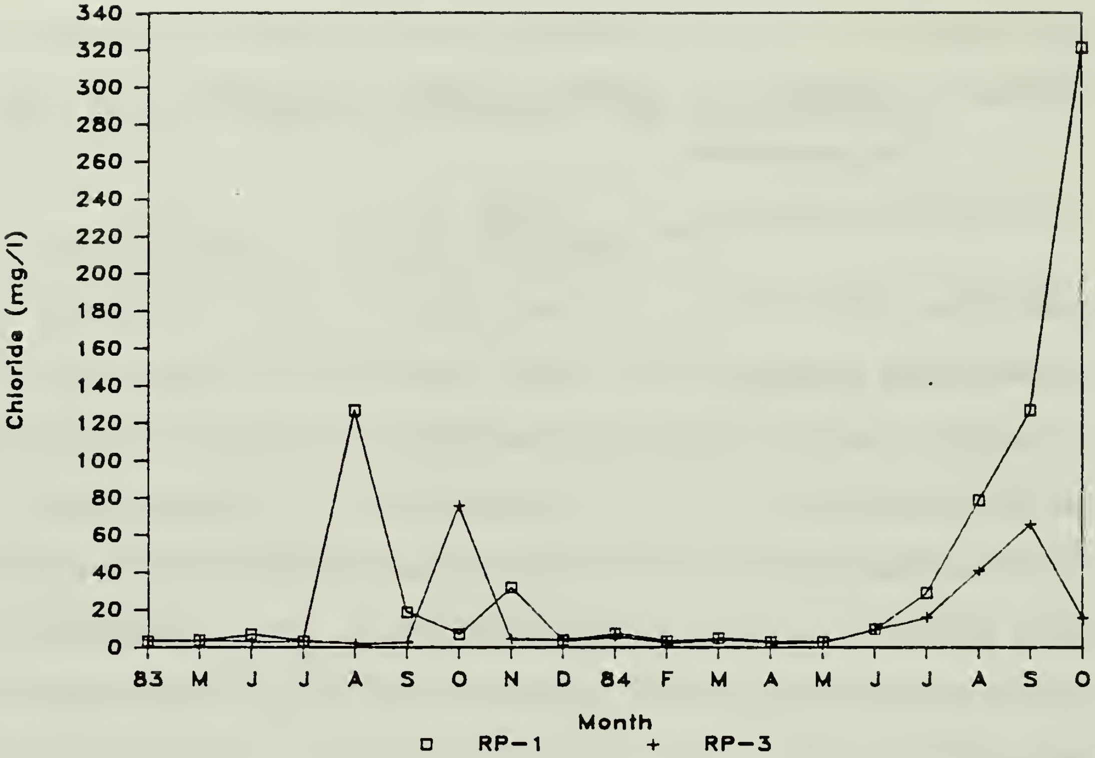


Figure 16. Seasonal fluctuations in chloride levels for sites RP-1 and RP-3 in Roaring Paunch Creek, a severely polluted stream.

O'Bara et al. (1982) reported the aquatic life as being stressed. However, the creek still supports a wide variety of aquatic life, including the Big South Fork Crayfish (Cambarus bouchardi), which is being reviewed for threatened or endangered status under the Endangered Species Act of 1973 (U.S. Fish and Wildlife Service, personal communication). Roaring Paunch Creek is the only stream in the U.S. in which this species has been found.

Rock Creek, Lower Reach (RO). The section of Rock Creek downstream from White Oak Junction in Kentucky is severely affected by acid mine drainage. Although a pH problem was not indicated at the RO-1 sampling site, O'Bara et al. (1982) noted that the White Oak Creek (Kentucky) watershed is extensively mined and recorded a pH level of 3.0 at an abandoned coal washing plant that drains directly into the creek. High concentrations of iron (over 0.3 mg/L), manganese (over 0.5 mg/L), and sulfate (over 25 mg/L) were found at the RO-1 site in Rock Creek. The stream bottom sediment also has the yellowish-orange color indicative of acid mine drainage.

DISCUSSION

In this section, we more closely examine the water quality data for a number of individual sites and categories of sites in order to discuss variations, seasonal patterns, and relationships found between certain parameters.

Seasonal Patterns and Stream Flow Relationships

As one would expect, levels of many of the water quality parameters fluctuated seasonally. Hardness, conductivity, and alkalinity, for example, are all related to total dissolved solids (TDS), and they become more concentrated at low flows during later summer and early fall. This is because a higher proportion of ground-water flow is in the streams during dry periods, and ground water typically has higher TDS levels than surface runoff. During the high flows of spring, more dilution is occurring as a result of surface runoff, so that dissolved substances, as reflected by TDS, become more dilute. In Figures 17-19, such seasonal changes can clearly be seen for alkalinity and conductivity, which have been plotted over time for three of the five different stream types.

The seasonal variations of concentrations of certain water quality constituents also can be seen in comparisons of these constituents to stream flow. Discharge records are available for two sites, NR-3 and CL-2. A comparison of discharge rates to alkalinity and conductivity values at these two sites (Figs. 20-23) shows the effect of concentrated dissolved solids on these parameters during low flow.

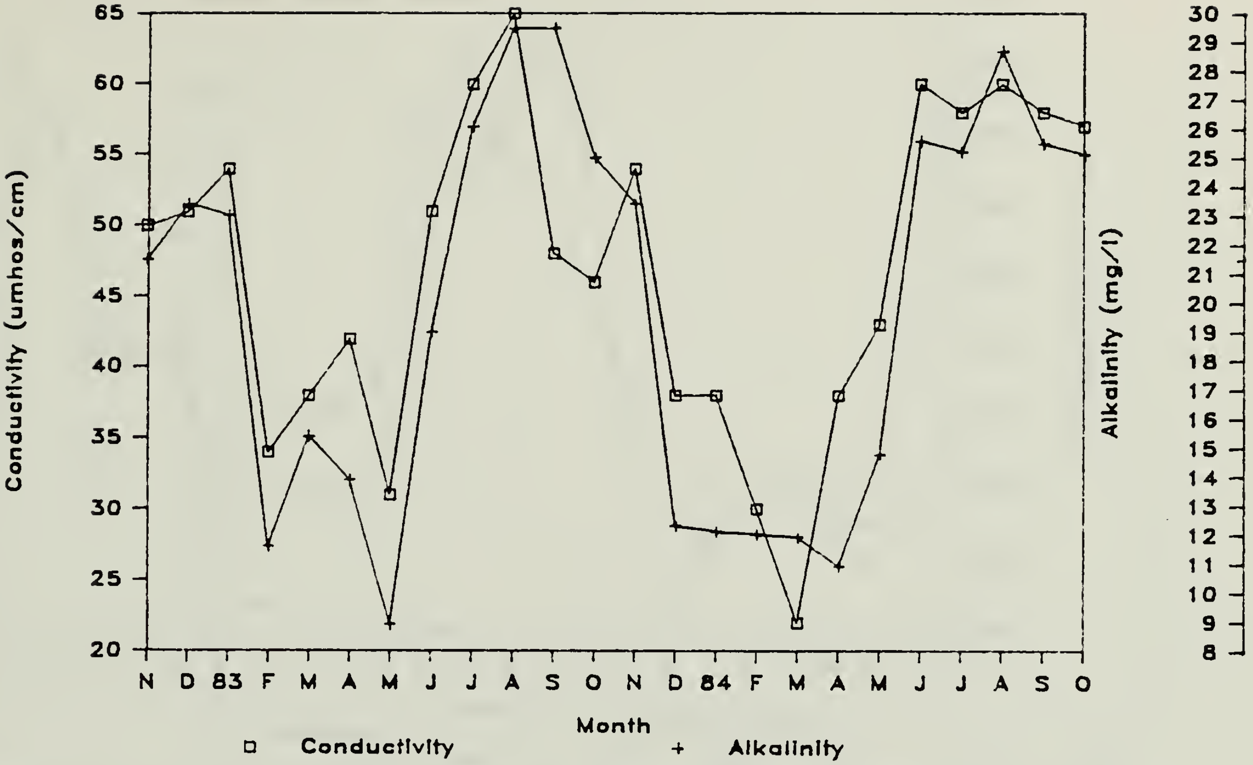


Figure 17. Seasonal fluctuations in conductivity and alkalinity levels for site SC-3 in Station Camp Creek, a clean/limestone-influenced stream.

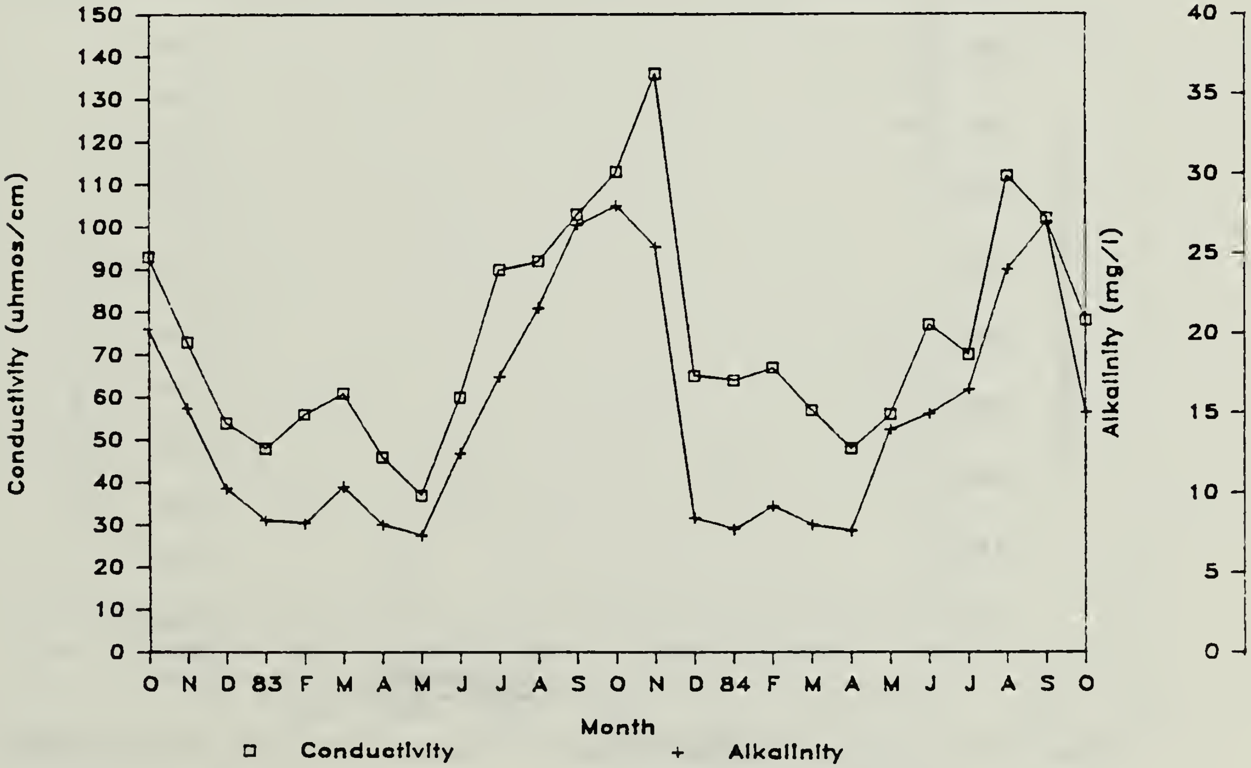


Figure 18. Seasonal fluctuations in conductivity and alkalinity levels for site CL-2 in Clear Fork, a slightly polluted stream.

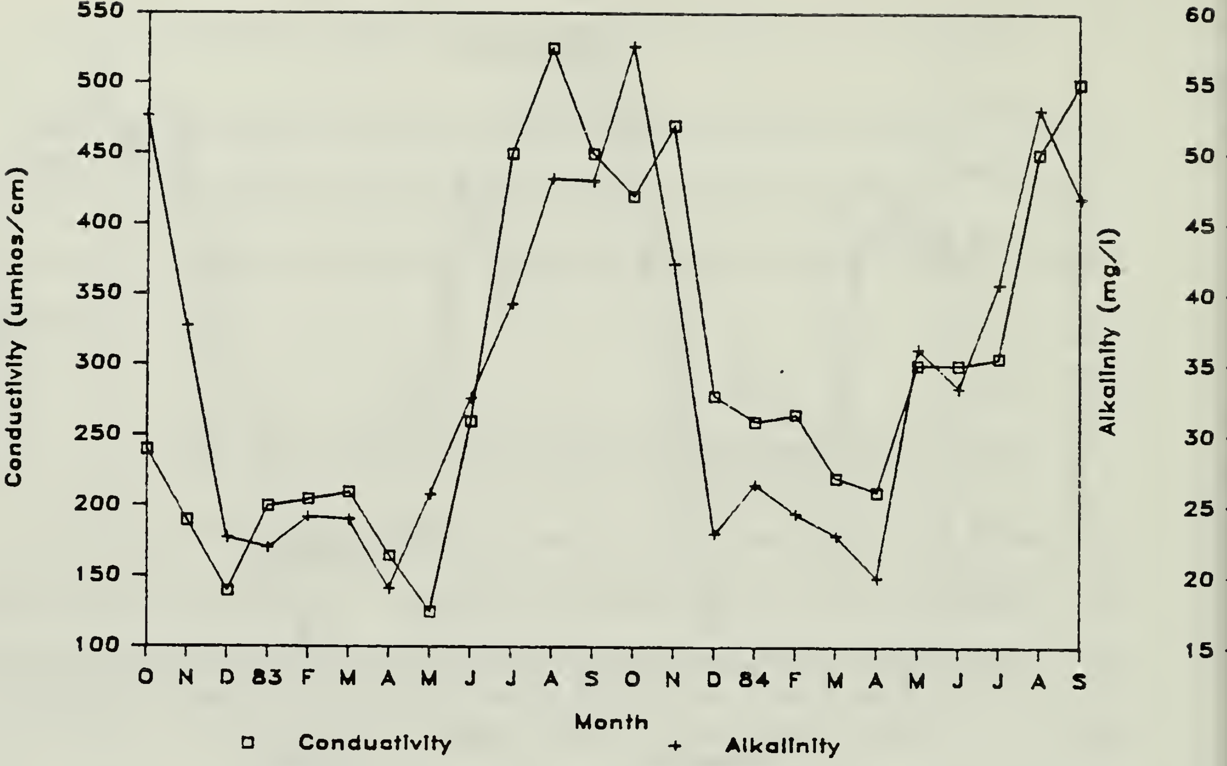


Figure 19. Seasonal fluctuations in conductivity and alkalinity levels for site NR-3 in New River, a moderately polluted stream.

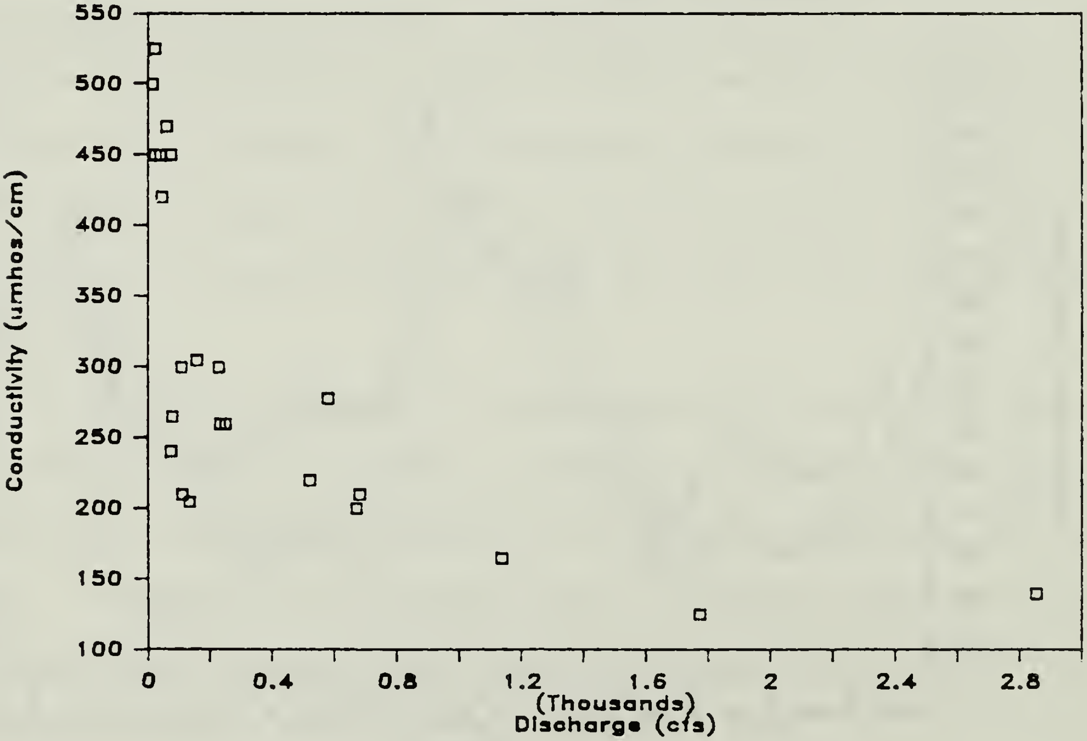


Figure 20. Plot of conductivity vs. stream discharge for site NR-3 in New River.

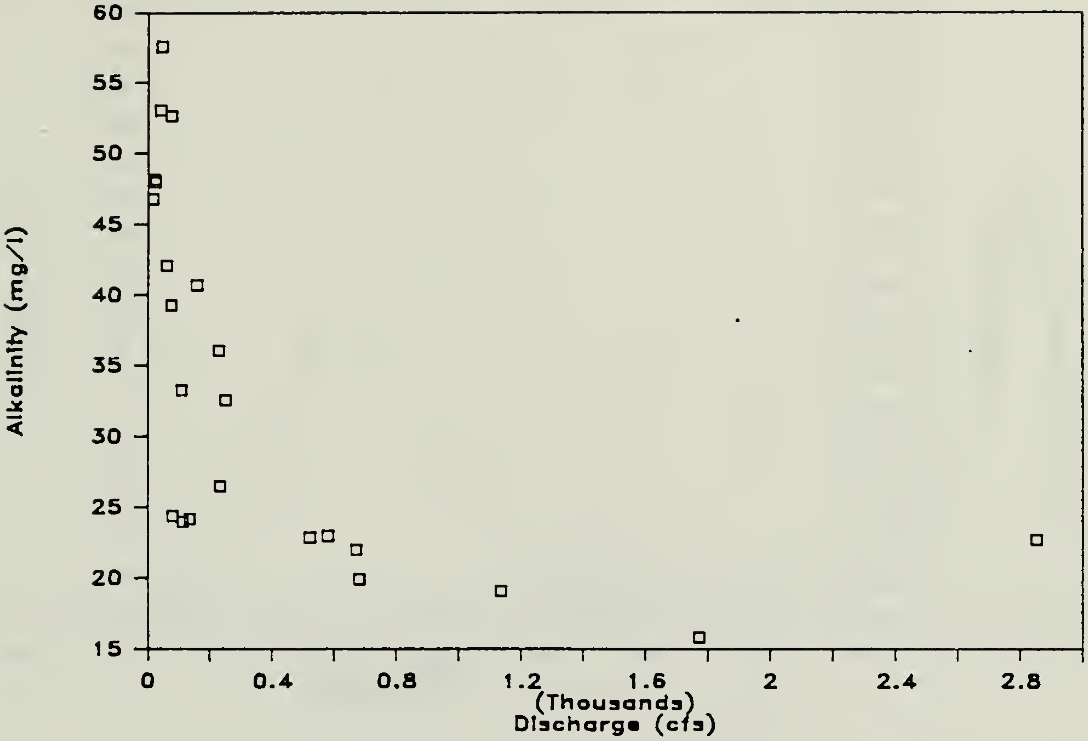


Figure 21. Plot of alkalinity vs. stream discharge for site NR-3 in New River.

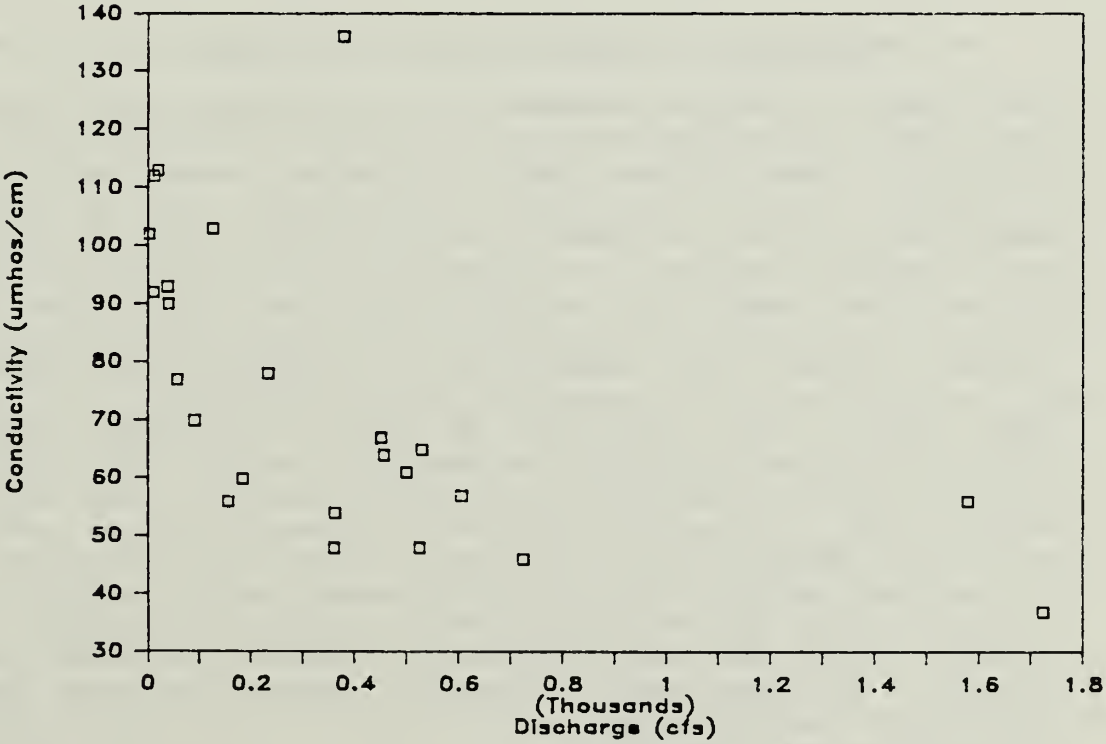


Figure 22. Plot of conductivity vs. stream discharge for site CL-2 in Clear Fork.

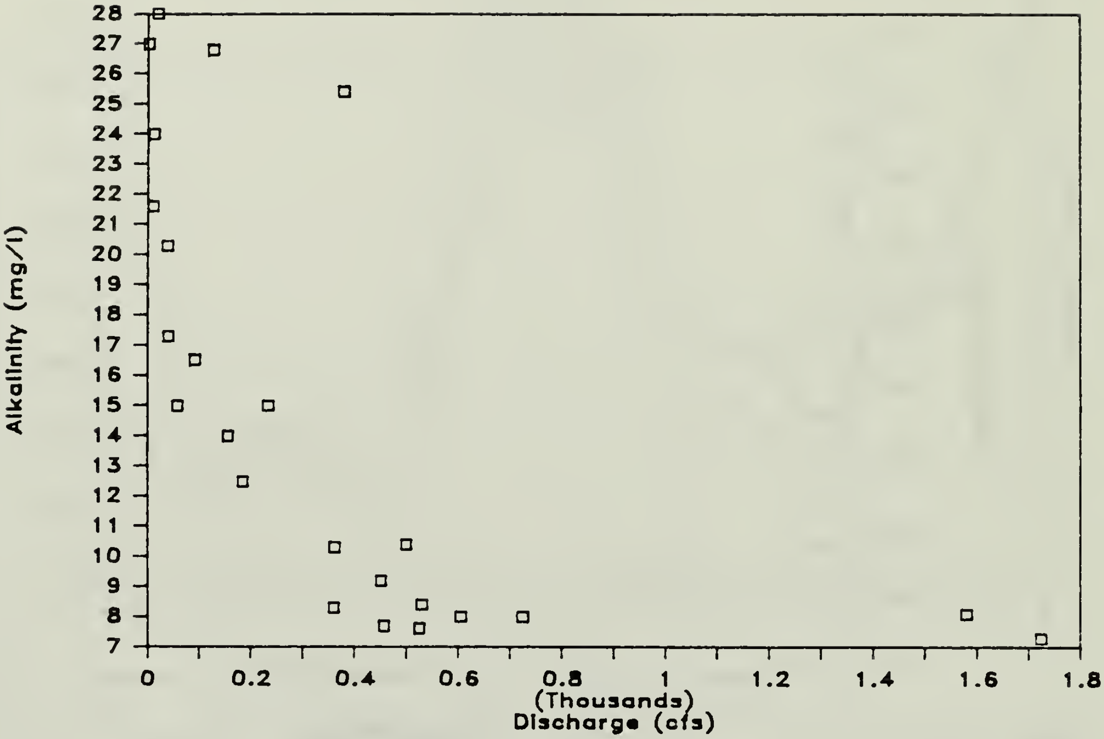


Figure 23. Plot of alkalinity vs. stream discharge for site CL-2 in Clear Fork.

As shown earlier in Figure 16, chloride levels in polluted streams also appear to fluctuate seasonally in correspondence with stream flow conditions, where chloride levels in Roaring Paunch Creek increased dramatically during late summer and early fall. Two other polluted streams, Pine Creek (PI-3) and White Oak Creek (WO-3), also show an increase, though a less dramatic one, in chloride levels during late summer and early fall (Fig. 24). The inverse relationship of pollutant concentrations to stream flow is a dilution function, since during dry periods the chlorides, which are known to move readily in ground water, continue to flow into the stream from the ground but are subject to less dilution. This phenomenon is frequently observed for other inorganic substances as well (Hem 1985).

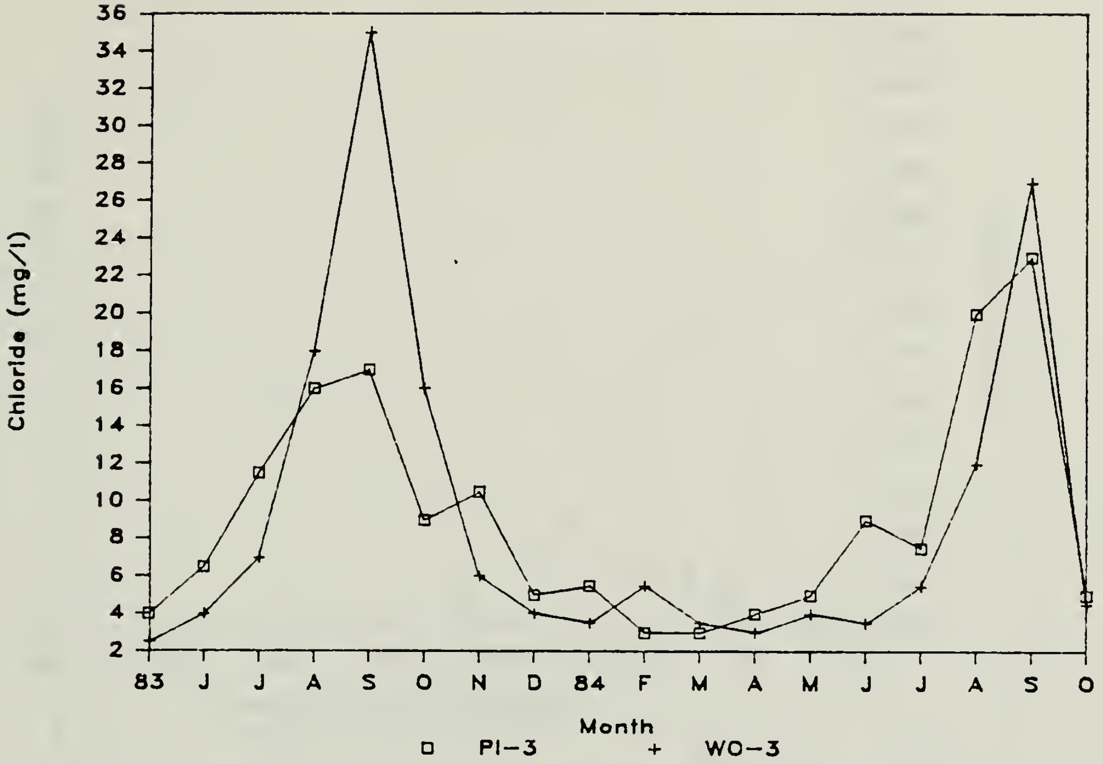


Figure 24. Seasonal fluctuations in chloride levels for site PI-3 in Pine Creek and site WO-3 in White Oak Creek.

Comparison of Some Water Quality Parameters

Conductivity is an effective indicator of hardness, total dissolved solids, and other inorganic, ionic substances in water. At BISO, hardness and conductivity were compared in a moderately polluted stream, Pine Creek, where they showed a strong relationship (r = 0.84, n = 21) (Fig. 25). Alkalinity (which reflects major anions) and hardness (which reflects major cations) were compared for Station Camp Creek, site SC-3, a clean stream affected by limestone, and again a high correlation (r = 0.97, n = 24) was demonstrated (Fig. 26). Because limestone is the major source of dissolved solids in Station Camp Creek, a high correlation (r = 0.88, n = 24) is also shown between alkalinity and conductivity (Fig. 27). These high correlations between hardness,

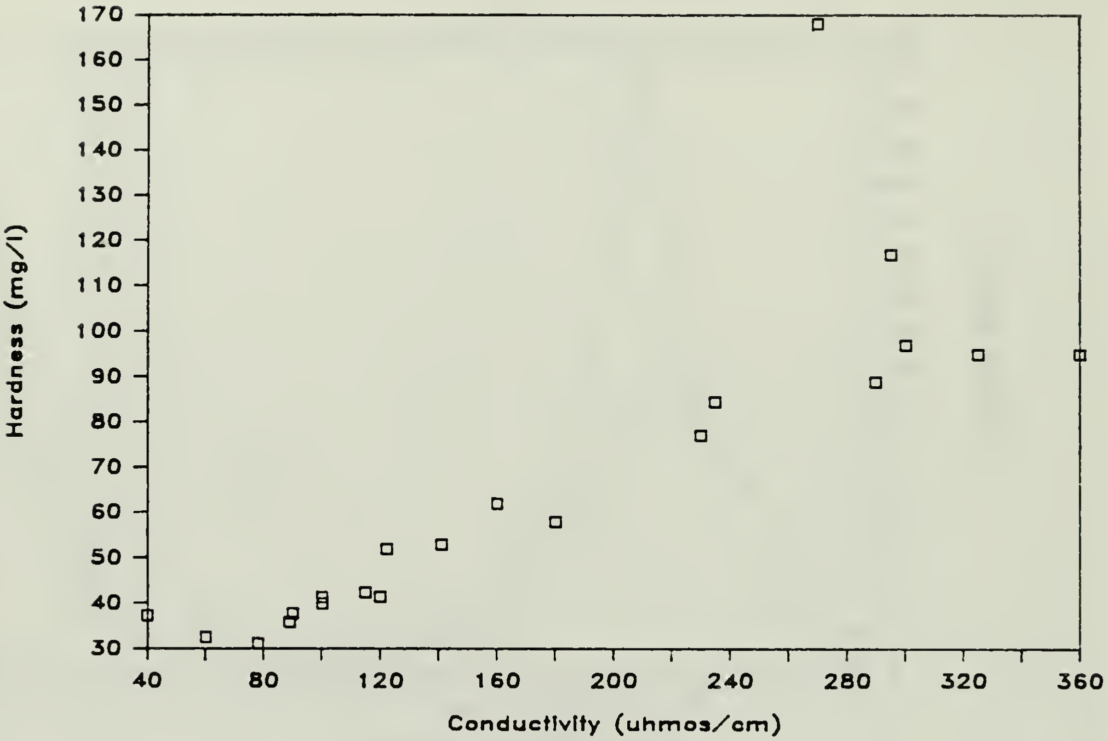


Figure 25. Plot of hardness vs. conductivity for site PI-3 in Pine Creek (r = 0.84, n = 21).

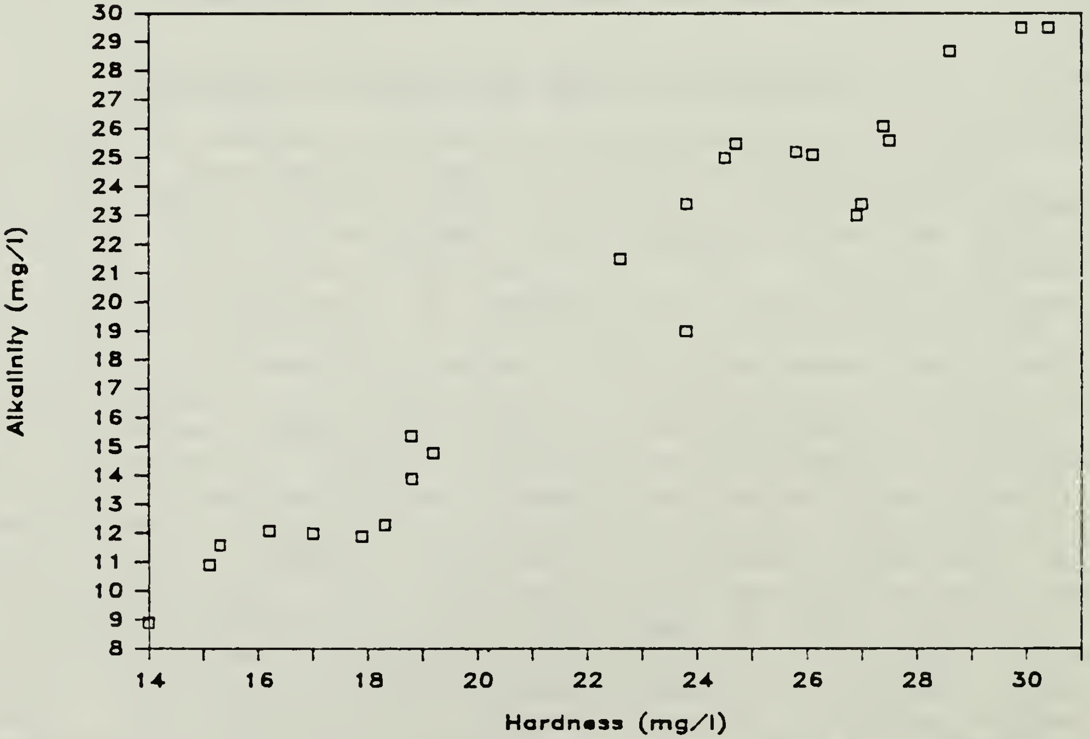


Figure 26. Plot of alkalinity vs. hardness for site SC-3 in Station Camp Creek (r = 0.97, n = 24).

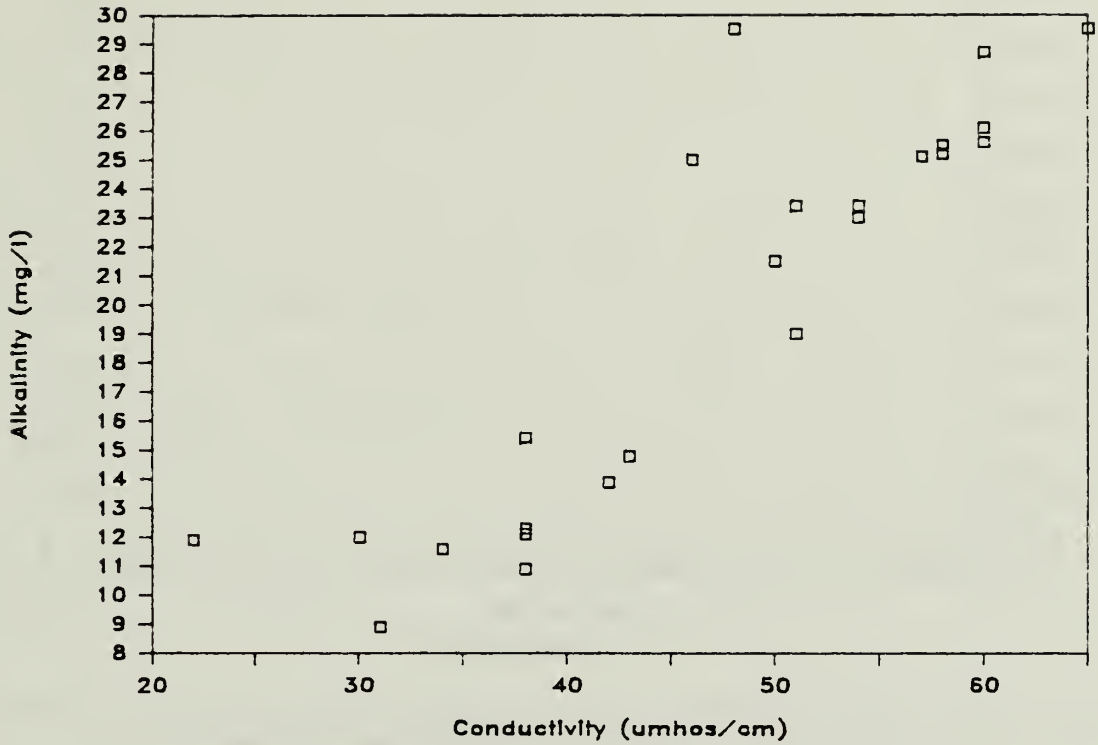


Figure 27. Plot of alkalinity vs. conductivity for site SC-3 in Station Camp Creek (r = 0.88, n = 24).

conductivity, and alkalinity might be expected since these parameters are all dependent on the dissolved solids content of the water. Bear Creek is an exception in which alkalinity does not correlate with hardness and conductivity, because the stream is so degraded by acid mine drainage that virtually no alkalinity is present.

Indicators of Coal Mining Impacts

Although pH is often thought to be a sensitive indicator of acid mine drainage, this was not the case in BISO waters. At Bear Creek site BR-1, for example, pH and sulfate levels correspond well, where lower pH is associated with higher sulfate concentrations (Fig. 28). On the

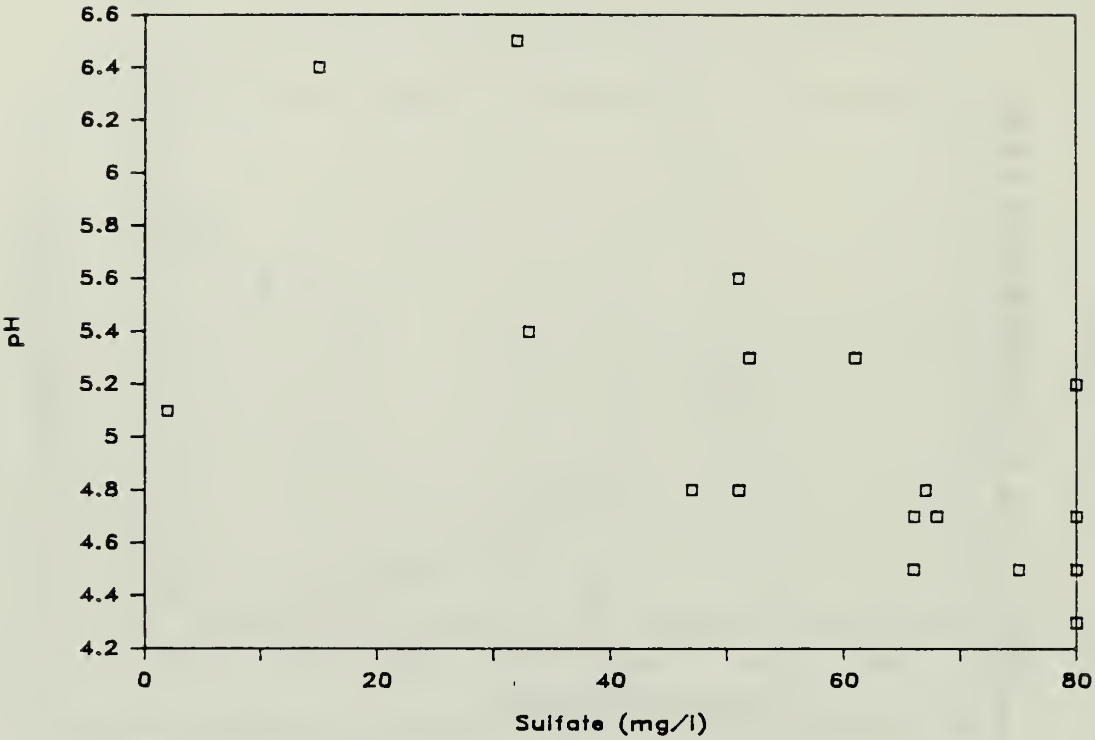


Figure 28. Plot of pH vs. sulfate for site BR-1 in Bear Creek (r = 0.69, n = 18).

the other hand, at Rock Creek site RO-1, these two parameters do not show this inverse relationship; in fact, pH readings are often near neutral even though high sulfate loads indicate acid mine contamination (Fig. 29). This lack of relationship between pH and sulfate levels holds true for most other sites and probably relates to the presence of alkaline earths and carbonates, which elevate alkalinity levels. In these instances, as in water at site RO-1, pH is buffered and does not reflect the high metals and sulfate loads. Only when alkalinity is lowered and metals and sulfate are relatively much higher—that is, when no buffering capability is left in the stream—will pH begin to reflect the influence of acid mine drainage. For this reason, sulfate and manganese serve as more reliable indicators of acid mine drainage than pH. These findings agree with those of Parker and Carey (1980), who

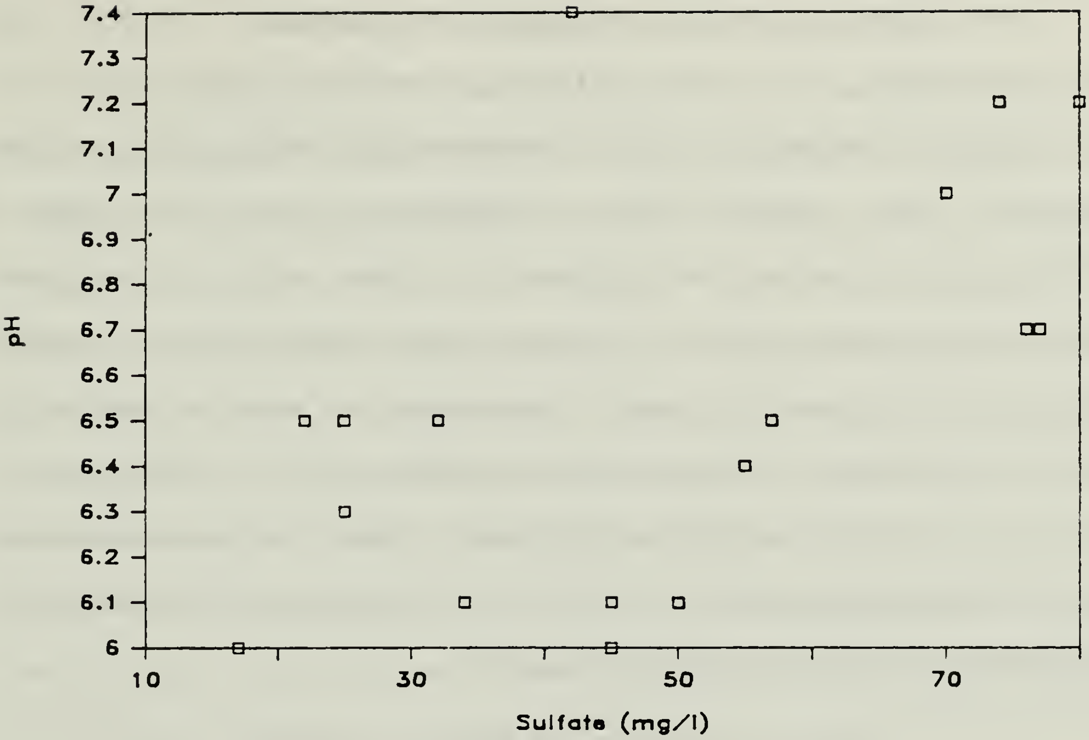


Figure 29. Plot of pH vs. sulfate for Site RO-1 in Rock Creek (r = 0.56, n = 17).

investigated the quality of water discharged from the New River and Clear Fork basins. They report that the water discharging from the heavily mined New River basin was characterized by neutral pH, low dissolved solids (<300 mg/L), and high concentrations of suspended sediment (approximately 590,000 tons, or 2.41 tons/acre, of suspended sediment were discharged from the New River basin in 1977). Upon comparing mined and unmined basins of New River and Clear Fork, the authors found the most reliable indicator of the presence of coal mining to be dissolved sulfate. All unmined basins in the study showed dissolved sulfate concentrations less than 20 mg/L, whereas all mined basins had dissolved sulfate concentrations in excess of 20 mg/L regardless of basin size or discharge (Parker and Carey 1980).

Another effective indicator of acid mine drainage in the BISO study was conductivity. All streams affected by acid mine drainage exhibited high levels of conductivity, which reflects dissolving metals and other compounds. Other metals, such as aluminum and copper, are known to indicate mining impacts, but analysis for these metals was not undertaken in the present study. For Lower Rock Creek, which is severely polluted by acid mine drainage, a comparison was made between acidity (more a reflection of anions) and hardness (more a reflection of cations, or total dissolved solids [TDS]). These two parameters showed a fairly strong relationship (r = 0.78, n = 20), indicating that acidity and TDS are also closely related (Fig. 30).

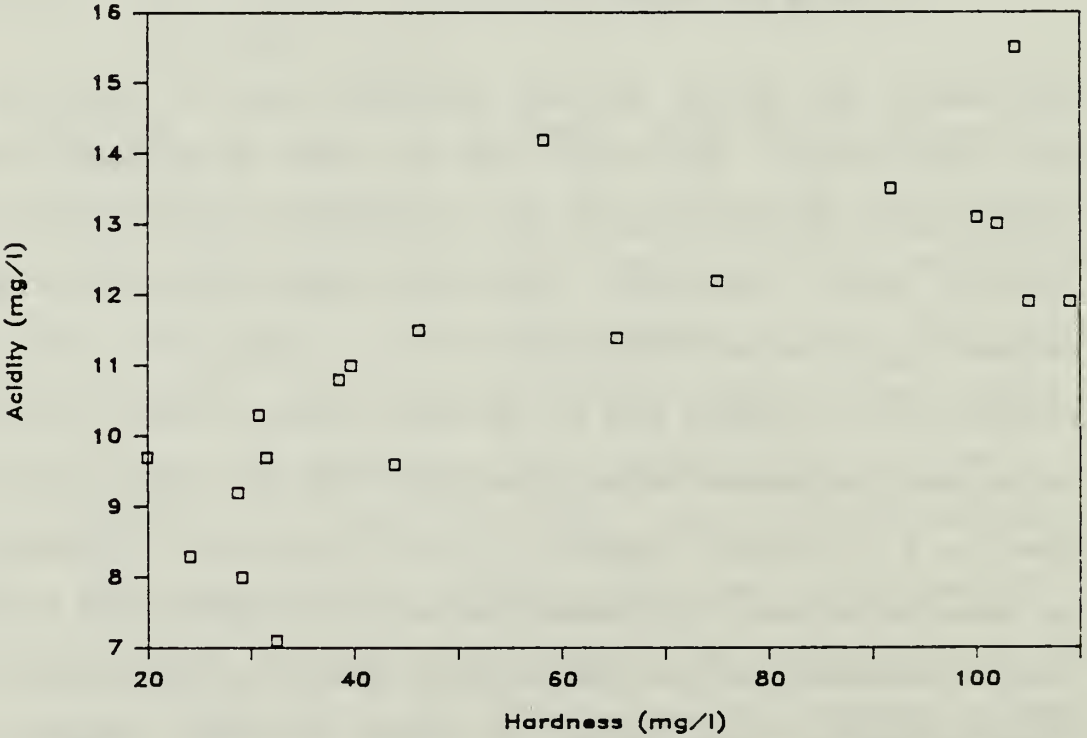


Figure 30. Plot of acidity vs. hardness for site RO-1 in Rock Creek (r = 0.78, n = 20).

MONITORING RECOMMENDATIONS AND CONCLUSIONS

This report provides park managers with an overview of the water quality situation within the Big South Fork NRRA by mapping out the stream reaches with serious pollution problems, those with minor impacts, and those that are undisturbed. With this information, managers can make sound resource management decisions relating to water use and water quality. Continued monitoring is necessary for maintaining stream quality, for detecting changes in stream quality, for observing clean-up results, and for obtaining background water quality data on streams not yet sampled. To this end, recommendations for further monitoring are given below. In the more distant future, the program can and should be modified as needs and objectives change.

Monitoring Recommendations

Based on what has been learned, the monitoring program for the Big South Fork NRRA can be modified slightly for more efficiency. Essentially the same sites should be continued in order to have a consistent data base; however, some adjustments are in order. Specifically, it is recommended that sites CL-3 and GR-3 be eliminated. Clear Fork shows no major changes downstream from CL-4 to CL-2, so that CL-3 could be eliminated and still leave three sites on this major stream. Since Grassy Fork of Williams Creek is a stream of good water quality, and because site GR-3 carries very little stream flow and becomes dry during the summer, it is recommended that GR-3 be eliminated. Pine Creek appears to improve in water quality as it flows through BISO; therefore, site PI-1 could be sampled only every three months. Because there is a great distance between the two sites on Rock Creek, it is suggested that site

RO-3 be eliminated and another site, RO-2, be established in the middle stretch of Rock Creek.

Additional streams that should be monitored are Mill Creek on North White Oak Creek, Parch Corn Creek, Troublesome Creek, and Difficulty Creek. As Mill Creek may be affected by abandoned mines and by ongoing strip-mining and oil and gas exploration, it should be sampled monthly. Parch Corn Creek, Troublesome Creek, and Difficulty Creek are more remote and access is difficult. As such, they are probably undisturbed at the present time, but they should be monitored to acquire background data in order to detect any changes. In view of their difficult access, every three months should be sufficient. A complete water quality monitoring program for all major tributaries is given in Tables 9 and 10. Table 9 lists the recommended frequency of sampling for each site and Table 10 gives a six-month sampling schedule, grouping those sites that can be sampled in one day. (Refer to Table 2 for stream names and abbreviations.)

In order for resource managers to protect water quality or reduce water pollution in the Big South Fork NRRA, they will need basic data on stream water quality, at least periodicially. The sampling schedule proposed in Table 9 represents a complete monitoring program for all major tributaries. Because the hydrologist on staff at BISO must conduct the laboratory analyses, maintain equipment, and collect samples, not only at BISO but also for the Obed Wild and Scenic River, a technician for at least 4 to 5 days a month is needed to maintain such a schedule. Therefore, BISO managers will need to review staffing needs if this suggested monitoring program is to be carried out.

Table 9. Recommended sampling frequencies for individual stream sites in BISO.

Monthly	Every 2 Months	Every 3 Months
BR-1	GR-1	CL-1
BR-3	LN-1	NB-1
BN-2	LS-1	NB-3
CL-2	LS-3	NR-1
CL-4	NW-1	RO-2
LN-3	PU-1	TR-1
NW-3	SC-2	TR-3
NR-3	SC-3	DF-1
PI-3	SC-4	DF-3
PU-4	WL-2	PA-1
RO-1	WL-3	PA-3
RP-1		PI-1
RP-3		
WO-3		
MC-1		

Table 10. Six-month sampling schedule for all sites in the Big South Fork NRRA.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Month 1	*BR-1 *RO-1 *RP-1 *RP-3	CL-2 CL-4 NR-3 NW-3 WO-3 MC-1 LN-1	BR-3 PI-3 PU-3 NW-1	*BN-2 *LN-3 *LS-3 *SC-3 *SC-4	*LS-1 *SC-2	NB-1 NB-3	PA-1 PA-3
Month 2	BR-1 RO-1 RP-1 RP-3	*CL-2 *CL-4 *NR-3 *NW-3 *WO-3 *MC-1	*BR-3 *PU-3 GR-1 PU-1 WL-2	BN-2 LN-3 *PI-3 *WL-3	NR-1 CL-1 PI-1	TR-1 TR-3	
Month 3	*BR-1 *RO-1 *RP-1 *RP-3	CL-2 CL-4 NR-3 NW-3 MC-1 LN-1 WO-3	BR-3 PI-3 PU-3 NW-1	*BN-2 *LN-3 *LS-3 *SC-3 *SC-4	*LS-1 *SC-2	DF-1 DF-3 RO-2	
Month 4	BR-1 RO-1 RP-1 RP-3	*CL-2 *CL-4 *NR-3 *NW-3 *WO-3 *MC-1	*BR-3 *PU-3 GR-1 PU-1 WL-2	BN-2 LN-3 *PI-3 *WL-3	PA-1 PA-3	NB-1 NB-3	
Month 5	*BR-1 *RO-1 *RP-1 *RP-3	CL-2 CL-4 NR-3 NW-3 WO-3 MC-1 LN-1	BR-3 PI-3 NW-1 PU-3	*BN-2 *LN-3 *LS-3 *SC-3 *SC-4	*LS-1 *SC-2	TR-1 TR-3	NR-1 CL-1 PI-1
Month 6	BR-1 RO-1 RP-1 RP-3	*CL-2 *CL-4 *NR-3 *NW-3 *WO-3 *MC-1	*BR-3 *PU-3 GR-1 WL-2 PU-1	DF-1 DF-3 RO-2			

*Bacteria samples to be collected at these sites.

Complete laboratory analysis is needed for samples from selected sites at regular intervals (every 3 to 6 months). This data would give a more complete and accurate measurement of metals and would substantiate other data. In addition, aluminum analysis should be conducted for those streams affected by acid mine drainage (i.e., Bear Creek, Rock Creek, Roaring Paunch Creek, Puncheoncamp Fork, and White Oak Creek). Because sewage can be monitored by bacteria, and because no major nutrient problems have been indicated by algal blooms or septic conditions, monitoring of nutrients is not recommended at this time.

Background data are also needed for fish and benthic organisms in BISO's waters. This type of data would indicate if aquatic fauna populations were improving or declining and would provide further evidence of pollution problems.

One major drawback to the present monitoring program is that most water quality data could not be correlated to stream flow because stream flow data was available only for two sites where USGS stations were operating. As water quality in general and seasonal fluctuations in particular are related to stream flow, it is recommended that staff gauges be established at selected sites and that rating curves be developed for these sites so that stream flow can be determined when a sample is taken.

Conclusions

Data collected to date show that the BISO area contains a number of pristine streams, but the polluted condition of other streams serves as an indication of water quality problems that are occurring and are likely to continue in the absence of any intervention.

The developing Big South Fork National River and Recreation Area shows great potential for providing a wide variety of recreational uses to its visitors. However, because the Big South Fork of the Cumberland River and its tributaries are the major resource for these uses, the water quality needs to be monitored as recommended in the preceding section.

If the staff of BISO are to maintain and improve the water quality in the recreation area, they must work to correct problems occurring both within and outside the boundary. Specifically, all mined areas within the boundary should be reclaimed, dirt roads should be stabilized, and seeping mine openings should be treated insofar as such adjustments are possible. Because many of the activities affecting water quality occur outside the park boundaries, the BISO staff must work closely with local, state, and federal officials in order to lessen outside influences on water quality. If such activities as strip mining, drilling, dumping of inadequately treated sewage, and road building are allowed to continue unchecked, they could result in diminished aesthetic qualities and the further reduction or loss of flora and fauna—with a consequent decline in visitor appeal. If, however, BISO's water resources are carefully protected, the Big South Fork National River and Recreation Area will continue to provide viable and safe recreation to the growing numbers of recreationists using its many resources.

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APPENDIX A

Water Quality Data

STATION NAME Bendy Creek, Site BN-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
12-22-82	1345	5.6	6.1	20	12.2	5.7	5.2	8.3		<0.2	<10		1.4					
01-14-83	1125	3.0	6.8	22	13.1	2.9	5.5	8.0		<0.2	<10		2.8					
02-04-83	1530	4.7	7.0	19	12.9	2.8	5.7	7.6		<0.2	<10		2.4					
04-21-83	1100	6.0	6.8	19	12.8	2.7	5.7	7.2	2.5	<0.2	<10	<0.5	1.7					
05-16-83	1450	12.4	6.4	20	10.5	2.7	5.0	6.9	2.5	<0.2	<10	<0.5	5.3					
06-09-83	1705	15.5	6.9	20	9.5	5.5	7.0	7.3	2.5	<0.2	<10	<0.5	8.5					
07-22-83	920	22.1	6.6	32	7.3	10.6	9.1	13.3	1.0	<0.2	<10	<0.5	3.8					
08-02-83	1340	21.8	6.2	35	4.5	11.8	12.6	15.0	1.0	<0.2	<10	<0.5	2.5					
11-08-83	1315	7.5	6.7	32	11.2	9.3	9.0	12.4	1.5	<0.2	<10	<0.5	2.8					
12-14-83	1415	8.7	6.4	22	11.3	4.6	4.2	10.5	1.0	<0.2	<10	<0.5	2.1					
MEAN		10.7	6.5	24	10.5	5.9	6.9	9.7	1.5				3.3					
MEDIAN		7.5	6.6	20	11.2	4.6	5.7	8.0	1.5	<0.2	<10	<0.5	2.5					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Bendy Creek, Site BN-2

DATE	TIME	TEMP	pH	COND	DO	ALK	ACID	HARD	Cl-	Fe	SO4	Mn	TURB	STAGE	STREAM	T COL	F COL	F STRP
				umhos											FLOW	#/	#/	#/
	hours	C		/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	NTU	ft	cfs	100ml	100ml	100ml
04-21-83																4	2	8
06-09-83	1645															16	31	1060
08-02-83	1315															0	53	30400
10-11-83	1540															104	40	13800
12-14-83	1350															25	4	3000
01-18-84	925	0.8	6.3	18	13.7	3.3	6.6	7.0	1.0	<0.2	<10	<0.5	0.8					
02-29-84	1250	3.9	6.9	21	12.2	3.0	6.3	7.2	1.0	<0.2	<10	<0.5	1.8			0	0	
03-19-84	1440	9.9	6.6	18	10.6	2.2	4.7	7.3	1.0	<0.2	<10	<0.5	1.6					
04-25-84	1405	11.7	6.5	18	10.8	3.1	4.6	7.2	1.0	<0.2	<10	<0.5	1.7			64	39	
05-17-84	1350	11.3	6.7	18	10.5	2.4	5.2	7.1	1.0	<0.2	<10	<0.5	1.9					
06-26-84	1320	17.3	6.3	18	8.9	4.8	8.4	8.3	1.0	<0.2	<10	<0.5	2.4			280	80	2200
07-30-84	1505	17.2		12	8.4	7.4	7.4	9.8	1.0	0.30	<10	<0.5	7.8					
08-23-84	935	18.0	5.7	19	8.8	7.5	10.1	9.0	1.5	0.45	<10	<0.5	8.5			1950	340	38000
09-06-84	1405	15.9	6.7	20	9.5	7.9	10.3	7.8	1.0	0.60	<10	<0.5	4.3					
10-15-84	930	13.6	7.0	20	9.2	8.7	9.2	10.1	1.0	0.65	<10	<0.5	3.2			40	0	
MEAN		12.0	6.4	18	10.3	5.0	7.3	8.1	1.1				3.4			248	59	12638
MEDIAN		11.7	6.6	18	9.5	3.3	6.6	7.3	1.0	<0.2	<10	<0.5	1.9			25	31	3000

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

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STATION NAME Bandy Creek, Site BN-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-17-82	950	7.0	5.8	12	10.1	3.0	7.6	5.9		<0.2	<10		2.0					
12-14-82	950	4.6	5.9	10	11.9	4.5	5.8	5.7		<0.2	<10		1.5					
01-06-83	1000	6.7	5.8	18	11.1	2.7	5.6	5.5		<0.2	<10		7.2					
02-04-83	950	5.7	6.8	18	11.7	2.9	5.3	6.8		<0.2	<10		1.3					
03-09-83	1005	9.3	6.6	17	10.7	3.0	5.3	6.8		<0.2	<10	<0.5	2.0					
04-20-83	915	7.0	6.5	18	11.7	2.3	5.1	7.7	2.4	<0.2	<10	<0.5	1.2					
05-16-83	950	12.5	5.9	20	9.6	2.6	6.5	7.0	2.5	<0.2	<10	<0.5	3.8					
06-09-83	1000	12.7	6.2	18	9.6	3.0	7.1	7.5	2.5	<0.2	<10	<0.5	3.0					
07-12-83	1550	19.3	6.2	13	8.2	4.1	7.1	6.0	1.5	<0.2	<10	<0.5	6.6					
08-02-83	915	20.0	6.1	13	7.4	5.0	7.1	6.5	1.0	0.45	<10	<0.5	9.1					
09-06-83	935	19.7	5.9	14	7.1	5.1	13.2	5.9	1.0	<0.2	<10	<0.5	8.3					
10-11-83	925	12.2	8.1	10	8.4	5.6	6.0	5.9	3.0	<0.2	<10	<0.5	3.7					
11-03-83	1535	13.4	5.9	17	8.1	6.9	10.8	8.1	1.5	0.20	<10	<0.5	3.2					
12-14-83	930	8.6	5.6	12	10.4	3.0	5.7	8.2	1.0	<0.2	<10	<0.5	2.7					
MEAN		11.3	6.0	15	9.7	3.8	7.0	6.7	1.8				4.0					
MEDIAN		9.3	5.9	14	9.6	3.0	6.0	6.5	1.5	<0.2	<10	<0.5	3.0					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Beer Creek, Site BR-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-27-82	1450	8.5	5.6	280	11.3	2.5	21.0	118.0		0.42			0.9					
12-07-82	750	11.0	5.3	123	11.6	2.3	9.9	44.8		<0.2	52		3.9					
01-08-83	800	7.0	5.1		13.0	2.5	16.9	71.2		0.25	>80		1.5					
01-30-83	910	7.5	4.7	140	12.0	2.0	12.8	52.5		0.20	68		4.3					
03-02-83	1045	8.0	4.8	140	12.7	2.3	13.9	51.2		<0.2	67	2.7	1.5					
04-19-83	950	6.3	4.7	138	12.2	2.9	10.4	47.8	2.4	<0.2	66	1.9	3.5					
05-17-83	1415	12.1	5.4	76	10.6	2.6	9.8	29.0	2.5	0.20	33	0.6	9.7					
06-14-83	1350	21.0	4.7		9.6	1.5	19.3	73.9	2.5	<0.2	80	1.4	1.7					
07-06-83	1010	20.4	4.5	180	8.7	2.2	18.0	67.7	2.5	<0.2	75	3.4	8.6			2	134	
08-16-83	945	21.0	5.2	190		2.6	11.4	79.4	3.5	<0.2	80	3.3	1.5			0	0	9200
09-09-83	940	19.7	5.6	220	7.0	4.0	9.7	72.0	12.0	<0.2	51	2.5	1.7					
10-03-83	1320	15.3	6.4	210	8.3	5.9	18.4	62.0	5.0	<0.2	15	<0.5	1.6			90	30	16400
11-01-83	1030	10.6	4.5	430	10.0	2.6	29.3	205.0	4.0	<0.2	>80	8.0	0.4					
12-05-83	955	8.9	5.1	121	11.1	3.7	9.4	38.1	1.0	<0.2	41	1.5	6.3			80	8	
01-09-84	1315	2.3	5.3	165	13.7	2.2	14.2	65.4	1.5	<0.2	61	3.1	1.0					
02-14-84	1205	7.9	6.5	91	12.0	1.5	13.0	34.1	3.0	<0.2	32	2.6	12.0			2	2	2700
03-06-84	1200	5.6	4.8	132	12.1	1.5	13.1	46.6	1.5	<0.2	51	2.1	3.1					
04-02-84	1020	6.6	4.8	126	12.2	2.8	11.9	42.8	1.5	0.20	47	1.7	1.8			1	0	
05-15-84	1330	14.4	4.5	179	9.8	1.5	17.8	65.2	1.5	<0.2	66	3.0						
06-04-84	1240	18.8	4.3	260	9.5	0.0	22.9	93.0	2.0	<0.2	>80	4.0	0.9			0	0	3600
07-12-84	1320	23.1	5.5	210	7.9	0.0	18.1	101.0	2.5	<0.2	>80	<0.5	2.1					
09-05-84	1200	17.7	4.5	325	8.7	1.7	18.1	120.0	5.0	<0.2	>80	3.3	1.0					
10-09-84	1420	15.4		255	9.3	2.0	14.6	100.0	1.5	0.25	>80	2.5	6.3			460	0	16584
MEAN		12.6	4.8	190	10.6	2.3	15.4	73.1	3.1				3.4			79	22	9697
MEDIAN		11.0	4.8	179	10.6	2.3	14.2	65.4	2.5	<0.2	66	2.5	1.7			2	2	9200

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Bear Creek, Site BR-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-01-82	1050	11.6	4.5	355	9.1													
01-13-83	1050	1.0	4.4	210	13.7	0.0	19.4	80.1		0.25	>80		4.0					
02-22-83	1255	7.5	4.1	260	11.8	0.0	27.3	102.3		0.40	>80		1.1					
03-23-83	1400		4.5	180	13.1	1.5	19.3	75.2		0.45	>80	3.7	3.6					
04-22-83	1230	8.8	4.2	175	11.7	1.0	15.4	62.0	2.5	<0.2	77	1.8	2.1			0	0	10
05-12-83	1330	13.0	4.5	165	10.5	0.0	15.8	80.1	2.5	<0.2	72	1.9	2.2					
06-13-83	1345	18.2	4.1	285	9.3	0.0	28.1	102.7	2.5	0.25	>80	2.6	1.4			30	0	700
07-22-83	1320	26.4	3.9	320	7.3	0.0	30.0	136.0	2.5	<0.2	>80	7.0	1.0					
08-08-83	1250	23.8	4.4	310	7.4	1.0	19.9	123.4	2.5	<0.2	>80	6.4	0.9			5	2	9400
10-24-83	1445	14.0	3.9	490	9.3	0.0	56.6	201.0	2.5	0.85	>80	9.9	1.3					
01-26-84	1425	0.1	5.5	171	12.6	0.0	16.2	55.8	2.5	0.20	54	2.6	5.8					
03-13-84	1130	5.2	4.2	271	11.8	0.0	30.9	98.2	2.0	1.60	>80	10.0	87.0			2	0	
05-16-84	1340	12.6	4.3	300	10.4	0.0	28.2	104.4	1.0	0.25	>80	4.7						
06-27-84	1230	20.4	4.2	450	8.4	0.0	38.6	150.0	2.0	0.35	>80	7.5	0.7			10	0	1200
07-23-84	1300	21.1	4.3	415	8.1	0.0	33.0	157.4	2.5	0.20	>80	6.0	0.8					
08-21-84	1130	19.6	4.2		8.5	0.0	33.4	145.0	2.0	0.20	>80	5.1	0.7					
10-11-84	1203	15.1	4.1	420	8.5	0.0	45.3	168.0	1.5	0.50	>80	5.0	1.0			0	0	
MEAN		13.7	4.2	299	10.1	0.2	28.6	115.1	2.2			5.3	7.6			4	0	1414
MEDIAN		13.0	4.2	285	9.3	0.0	28.1	102.7	2.5	0.26	>80	5.0	1.3			5	0	700

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Clear Fork, Site CL-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-22-82	1100	12.0	7.4	100	10.5	21.6	17.2	34.7		<0.2			1.3					
12-07-82	1040	12.7	6.7	52	10.0	10.1	10.0	16.8		<0.2	<10		10.0					
01-13-83	1045	4.8	7.1	49	13.2	8.4	5.4	16.9		<0.2	<10		4.0					
02-01-83	1030	5.7	7.2	58	12.5	8.1	5.6	20.0		<0.2	10		4.0					
03-03-83	1205	8.6	7.3	62	11.5	11.1	7.8	19.2		<0.2	10		2.0					
04-12-83	1425	12.0	6.7	50	11.7	8.4	5.7	16.1	4.0	<0.2	<10	<0.5	5.3					
05-05-83	1300	13.0	6.9	39	10.4	7.2	7.0	14.2	3.0	<0.2	<10	<0.5	17.0					
06-10-83	1130	19.5	7.2	65	8.8	13.4	7.5	21.7	3.5	<0.2	10	<0.5	3.4					
07-05-83	1120	26.7	7.3	150	7.7	22.0	6.6	36.8	20.4	<0.2	12	<0.5	2.1					
08-10-83	1055	26.8	7.2	100	7.3	22.3	8.2	27.9	7.0	<0.2	15	<0.5	1.9					
09-01-83	1400	27.9	7.3	105	7.5	28.7	6.8	28.0	8.5	<0.2	10	<0.5	0.8					
10-18-83	1135	13.5	6.9	172		41.3	15.0	35.8	18.5	<0.2	<10	<0.5	2.5					
11-07-83	1035	9.9	6.5	135	10.8	27.8	11.8	35.2	8.5	<0.2	15	<0.5	0.8					
01-16-84	1040	2.0	6.6	57	13.8	7.7	5.7	18.7	4.5	<0.2	<10	<0.5	1.9					
03-15-84	1055	6.7	7.1	52	11.8	8.0	6.4	18.8	6.0	<0.2	10	<0.5	2.3					
05-21-84	1000	18.0	7.1	60	8.9	11.3	7.8	16.0	3.0	<0.2	11	<0.5	1.9					
07-16-84	1045	24.7	6.8	78	7.8	18.7	14.1	25.0	3.5	0.20	<10	<0.5	15.0					
09-11-84	1010	17.9	6.6	108	8.1	27.1	9.0	27.0	10.0	<0.2	<10	<0.5	0.5					
10-19-84	1005	19.2	7.2	168	8.4	41.3	14.0	37.0	20.0	<0.2	<10	<0.5	0.6					
MEAN		14.8	6.9	87	10.0	18.1	9.0	24.5	8.6				4.1					
MEDIAN		13.0	7.1	65	10.0	13.4	7.8	21.7	6.0	<0.2	<10	<0.5	2.1					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

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STATION NAME Clear Fork, Site CL-2

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-22-82	1230	12.9	6.6	93	9.9	20.3	18.5	30.2		<0.2			1.2	1.54	40.0			
12-06-82	1250	13.0	6.4	54	10.0	10.3	10.5	16.6		<0.2	<10		16.0	2.73	362.0			
01-13-83	1415	4.9	7.0	48	12.7	8.3	5.7	16.1		<0.2	<10		3.8	2.72	360.0			
02-01-83	1210	5.5	7.1	56	12.0	8.1	5.7	20.2		<0.2	10		3.3	4.62	1580.0			
03-03-83	1400	8.9	7.2	61	10.7	10.4	8.2	20.3		<0.2	10		2.0	3.00	500.0			
04-12-83		11.7	6.9	46	11.0	8.0	6.0	16.3	4.0	<0.2	<10	<0.5	5.0	3.40	724.9			
04-20-83																130	26	700
05-05-83		13.8	7.0	37	9.5	7.3	7.4	13.6	3.0	<0.2	<10	<0.5	12.0	4.80	1724.0			
06-08-83	1450	18.1	7.3	80	8.8	12.5	6.2	22.0	4.0	<0.2	10	<0.5	7.6	2.26	184.2			
06-13-83	950															0	0	2300
07-07-83	1555	25.9	7.0	90	7.1	17.3	11.1	31.1	5.0	<0.2	16	<0.5	3.5	1.55	41.0			
08-04-83	1445	29.2	7.3	92	7.5	21.6	7.0	28.4	5.0	<0.2	20	<0.5	1.8	1.21	11.5			
08-08-83	915															4	6	7600
09-12-83	1500	26.8	7.3	103	8.1	26.8	10.4	30.6	6.0	<0.2	10	<0.5	1.0	2.05	128.0			
10-11-83	930															0	8	2400
10-24-83	920	14.5	5.8	113	8.6	28.0	12.7	32.9	6.5	<0.2	13	<0.5	2.6	1.35	21.0			
11-17-83	925	6.4	6.4	136	11.3	25.4	8.0	43.2	8.5	<0.2	23	<0.5	6.6	2.77	380.6			
11-29-83	940															36	1048	
12-01-83	945	6.2	6.3	65	11.2	8.4	6.1	19.4	6.0	<0.2	<10	<0.5	5.7	3.06	530.3			
01-12-84	1255	0.4	6.6	64	14.0	7.7	6.3	19.4	4.5	<0.2	11	<0.5	8.8	2.92	455.8			
02-08-84	1235	0.6	6.7	67	13.8	9.2	6.4	19.9	5.0	<0.2	12	<0.5	1.3	2.91	450.5	0	0	1500
03-08-84	1530	5.7	7.1	57	12.6	8.0	6.8	19.3	3.5	<0.2	<10	<0.5	2.4	3.20	605.5			
04-11-84	1235	12.2	7.0	48	10.7	7.6	6.7	16.0	3.0	<0.2	<10	<0.5	2.4	3.05	525.1	4	4	40
05-22-84	940	18.9	7.2	56	8.4	14.0	8.9	20.1	2.5	<0.2	<10	<0.5	1.7	2.16	155.7			
06-07-84	1300	23.8	7.3	77	8.3	15.0	7.6	23.9	3.5	<0.2	13	<0.5	1.4	1.68	58.2			
07-10-84	1455	24.9		70	8.1	16.5	9.7	29.3	3.5	<0.2	<10	<0.5	22.0	1.88	92.2	90	30	16000
08-29-84	1040	24.1	7.4	112	7.8	24.0	10.8	27.2	8.0	<0.2	<10	<0.5	1.2	1.24	13.1	20	0	1000
09-20-84	830	17.1	6.9	102	7.6	27.0	13.8	28.6	8.5	<0.2	<10	<0.5	1.0	1.05	3.7			
10-30-84	955	16.8	5.9	78	9.0	15.0	9.7	23.0	6.5	<0.2	<10	<0.5	2.4	2.41	233.9	50	10	
MEAN		14.3	6.7	74	9.9	14.9	8.8	23.6	4.8				4.9	2.5	382.6	33	113	3943
MEDIAN		13.0	7.0	65	9.5	12.5	7.6	20.3	5.0	<0.2	<10	<0.5	2.4	2.41	233.9	4	8	1500

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME   Clear Fork, Site CL-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-09-82	1115	5.6	6.6	68	11.3	10.9	10.7	22.8		<0.2			1.4					
12-07-82	1045	10.6	6.1	48	11.2	7.6	7.2	13.9		<0.2	<10		4.0					
01-03-83	1100	7.0	6.0	40	11.8	8.0	8.1	14.0		<0.2	<10		2.1					
01-31-83	1130	5.7	7.2	41	11.9	7.2	5.8	14.3		<0.2	<10		2.3					
03-02-83	1025	7.0	7.1	43	11.3	8.1	5.3	13.9		<0.2	<10	<0.5	1.6					
04-06-83	1015	10.0	6.4	36	10.5	5.0	8.1	11.9		<0.2	<10	<0.5	33.0					
05-04-83	1115	12.4	6.7	36	9.6	7.8	7.9	14.4	4.0	<0.2	<10	<0.5	26.0					
06-08-83	1100	15.5	7.0	46	8.8	9.6	6.9	15.9	4.0	<0.2	<10	<0.5	3.9					
07-07-83	1115	22.6	6.9	53	6.6	15.0	10.0	19.7	3.0	<0.2	<10	<0.5	3.4					
08-04-83	1050	25.8	6.8	78	6.3	18.7	9.6	26.0	4.0	<0.2	12	<0.5	4.3					
09-12-83	1030	23.3	6.6	75	5.4	22.3	11.8	23.4	5.0	<0.2	<10	<0.5	2.8					
10-24-83	1225	14.5	6.8	85	7.2	16.9	11.6	25.7	6.5	<0.2	10	<0.5	1.7					
11-17-83	1215	6.1	6.7	82	11.4	13.4	7.9	26.2	7.0	<0.2	13	<0.5	3.3					
12-01-83	1315	6.3	6.3	63	10.8	7.6	6.7	18.9	7.0	<0.2	<10	<0.5	3.1					
01-12-84	1010	0.2	6.8	62		8.0	8.4	18.9	4.5	<0.2	<10	<0.5	3.9					
02-08-84	1010	0.1	6.4	55	13.7	6.3	6.2	16.4	4.0	<0.2	<10	<0.5	1.0					
03-08-84	1010	4.6	6.8	50	12.5	7.1	6.7	16.5	4.5	<0.2	<10	<0.5	1.4					
04-11-84	1000	10.6	6.9	43	10.2	5.7	6.5	13.4	3.0	<0.2	<10	<0.5	1.6					
05-22-84	1240	17.1	7.4	42	8.4	9.3	8.2	14.6	2.5	<0.2	<10	<0.5	1.9					
06-07-84	1050	21.0	6.9	52	7.5	13.2	6.3	17.5	3.0	<0.2	<10	<0.5	1.3					
07-10-84	1155	21.9		63	7.4	14.7	7.9	25.1	4.0	<0.2	<10	<0.5	12.0					
08-29-84	1300	22.9	7.0	77	7.0	19.8	11.1	22.2	7.5	<0.2	<10	<0.5	2.3					
09-20-84	1140	16.1	7.2	90	7.5	23.6	13.3	20.7	7.5	<0.2	<10	<0.5	2.6					
10-30-84	1400	16.9	6.9	68	9.5	13.0	10.3	21.4	6.5	<0.2	<10	<0.5	2.3					
MEAN		12.7	6.6	58	9.5	11.5	8.4	18.7	4.6				5.1					
MEDIAN		10.6	6.8	53	9.6	9.3	7.9	17.5	4.0	<0.2	<10	<0.5	2.3					

* Note   mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Clear Fork, Site CL-4 ✓

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-09-82	1220	8.0	6.7	60	11.6	11.8	10.5	20.2		<0.2			1.0					
12-07-82	1130	10.5	6.0	46	10.8	8.0	7.6	14.0		<0.2	<10		3.5					
01-03-83	1150	7.4	6.1	38	11.9	6.1	5.6	13.8		<0.2	<10		2.1					
01-31-83	1215	6.3	7.0	44	12.1	6.8	7.2	14.4		<0.2	<10		2.2					
03-02-83	1105	6.7	7.2	42	11.2	8.4	5.2	15.3		<0.2	<10	<0.5	2.2					
04-06-83	1050	10.0	6.7	41	10.2	7.7	7.4	15.1		<0.2	<10	<0.5	20.0					
04-20-83																40	16	20
05-04-83	1155	12.4	6.5	43	9.6	6.8	7.5	13.8	4.0	<0.2	<10	<0.5	20.0					
06-08-83	1145	14.9	7.1	58	9.6	10.6	5.2	21.2	4.0	<0.2	12	<0.5	3.5					
06-13-83	1040															140	10	2850
07-07-83	1200	22.6	7.0	56	8.0	15.0	11.0	20.9	2.5	<0.2	<10	<0.5	2.3					
08-04-83	1130	24.7	7.1	72	7.7	16.8	7.4	26.5	3.0	<0.2	14	<0.5	2.1					
08-08-83	1015															0	105	9000
09-12-83	1115	21.9	7.0	60	8.0	19.5	10.0	27.1	4.0	<0.2	<10	<0.5	2.0					
10-11-83	1020															12	0	8400
10-24-83	1145	14.0	6.9	65	8.1	18.6	12.2	22.6	4.5	<0.2	<10	<0.5	1.6					
11-17-83	1145	7.3	6.5	82	11.7	12.7	6.5	26.6	6.0	<0.2	17	<0.5	5.2					
11-29-83	1030															128	268	
12-01-83	1245	5.8	6.3	63	10.9	6.4	5.2	19.0	4.5	<0.2	<10	<0.5	4.0					
01-12-84	1100	0.3	7.6	61		7.9	6.2	19.1	4.0	<0.2	<10	<0.5	3.7					
02-08-84	1050	0.1	6.6	43	14.0	6.4	6.7	18.0	3.5	<0.2	11	<0.5	1.8			0	1	1700
03-08-84	1050	4.9	6.8	47	12.1	4.9	5.7	14.5	4.0	<0.2	<10	<0.5	1.0					
04-11-84	1030	10.8	6.8	41	10.4	5.9	6.1	12.9	3.0	<0.2	<10	<0.5	1.2			6	8	40
05-22-84	1200	17.1	7.2	42	9.2	9.2	7.0	14.3	2.0	<0.2	<10	<0.5	1.8					
06-07-84	1120	21.1	7.1	54	8.6	11.0	5.3	16.8	2.5	<0.2	<10	<0.5	1.3					
07-10-84	1255	23.0		63	8.4	13.5	7.1	25.4	4.0	<0.2	<10	<0.5	12.0			320	140	10400
08-29-84	1205	22.0	7.3	88	8.0	23.2	11.7	26.7	7.5	<0.2	<10	<0.5	1.6			160	0	6000
09-20-84	1105	16.8	7.4	88	8.4	25.3	11.0	27.0	6.0	<0.2	<10	<0.5	1.4					
10-30-84	1325	16.7	6.2	71	9.4	10.4	8.5	21.2	6.5	<0.2	<10	<0.5	1.5			100	40	
MEAN		12.7	6.7	57	10.0	11.4	7.7	19.4	4.2				4.1			91	59	4801
MEDIAN		10.8	6.9	56	9.6	9.2	7.1	19.0	4.0	<0.2	<10	<0.5	2.1			40	10	2850

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Grassy Fork of Williams Creek, Site GR-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-01-82	1410	13.7	7.1	13	9.5													
12-10-82	1210	6.0	5.7	18	11.9	4.1	8.0	5.7		<0.2	<10		1.5					
01-04-83	1130	3.5	5.6	16	12.6	2.5	5.6	5.5		<0.2	<10		2.0					
02-22-83	1020	6.3	6.1	18	12.5	2.6	5.3	6.7		<0.2	<10		1.2					
03-23-83	1010	3.8	6.5	15	13.0	2.9	5.5	6.8		<0.2	14		1.7					
04-22-83	1015	7.4	6.2	16	12.3	2.6	5.4	6.5	2.5	<0.2	<10	<0.5	2.0					
05-12-83	1055	12.4	5.9	18	10.1	2.9	4.7	4.6	2.5	<0.2	<10	<0.5	1.6					
06-13-83	1045	14.1	6.0	14	9.6	4.0	6.2	5.1	2.5	<0.2	<10	<0.5	1.7					
07-11-83	1215	18.1	6.4	15	8.6	2.3	7.3	5.6	2.5	<0.2	<10	<0.5	1.9					
08-08-83	1045	20.5	7.2	16	8.4	2.8	9.9	5.2	1.0	<0.2	<10	<0.5	1.6					
09-14-83	1040	17.7	8.1	15	8.5	4.6	4.8	7.1	3.0	<0.2	<10	<0.5	1.5					
10-24-83	1055	13.3	6.2	22	9.6	4.8	7.6	8.5	1.5	<0.2	<10	<0.5	1.3					
11-11-83	1020	7.3	7.3	22	11.1	5.8	7.2	7.6	1.5	<0.2	<10	<0.5	0.8					
12-13-83	930	7.6	7.0	15	11.8	3.5	4.8	6.7	1.0	<0.2	<10	<0.5	1.0					
02-17-84	940	6.3	5.8	18	11.9	2.2	5.0	6.1	1.0	<0.2	<10	<0.5	1.2					
03-13-84	925	4.0	6.2	18	12.4	2.0	5.1	8.2	1.0	<0.2	<10	<0.5	0.9					
04-04-84	1010	8.8	5.7	18	11.7	2.5	7.6	6.0	1.0	<0.2	<10	<0.5	4.9					
05-16-84	1150	10.0	6.3	17	10.7	2.9	5.3	6.7	1.0	<0.2	<10	<0.5						
06-27-84	1000	16.0	6.2	15	9.1	3.8	7.2	7.5	1.0	<0.2	<10	<0.5	0.9					
07-23-84	1120	17.8	6.2	16	9.1	3.7	6.9	5.5	1.5	<0.2	<10	<0.5	1.0					
08-21-84	1005	17.3	7.6		8.8	6.3	8.6	5.9	1.0	<0.2	<10	<0.5	1.0					
10-11-84	1050	14.1	5.8	19	9.2	4.8	8.8	5.4	1.0	<0.2	<10	<0.5	0.9					
MEAN		11.2	6.1	17	10.6	3.5	6.5	6.3	1.5				1.5					
MEDIAN		10.1	6.2	16	10.1	2.9	6.2	6.1	1.0	<0.2	<10	<0.5	1.3					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Grassy Fork of Williams Creek, Site GR-3

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DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-15-82	1450	8.0	6.4	19	10.4	8.1	11.7	8.5		<0.2	<10		9.0					
12-16-82	1455	10.0	4.6	17	10.2	2.5	8.3	5.5		<0.2	<10		5.5					
01-21-83	1325	6.5	5.8	17	11.3	3.0	5.8	5.0		<0.2	<10		3.3					
02-14-83	1350	7.0	6.7	31	12.0	3.1	5.6	5.0		<0.2	<10		2.1					
03-07-83	1400	12.2	5.8	14	9.7	3.1	7.4	4.0		<0.2	<10		4.5					
04-18-83	1430	8.8	5.7	14	11.1	2.8	6.9	5.1	2.4	<0.2	<10	<0.5	4.4			60	6	410
05-09-83	1420	12.3	5.4	14	9.2	2.6	10.0	4.0	2.5	<0.2	<10	<0.5	4.8					
06-03-83	1020	13.1	5.8	12	5.8	2.6	6.5	4.4	2.5	<0.2	<10	<0.5	6.0					
06-09-83	1440															70	10	620
07-22-83	1045	21.2	5.7	15	4.2	4.0	17.0	5.7	1.0	0.40	<10	<0.5	6.9					
08-09-83		DRY																
10-11-83		DRY																
11-30-83	1245	8.7	6.2	20	9.9	2.4	6.0	5.5	1.0	<0.2	<10	<0.5	2.3			232	12	6600
02-16-84	1100	7.2	5.4	17	11.2	3.7	6.0	3.8	1.0	<0.2	<10	<0.5	1.8			243	145	
04-26-84	1340	13.1		14	10.3	2.4	7.5	5.4	1.0	<0.2	<10	<0.5	2.2			13	9	
06-29-84		DRY																
08-27-84	1440	DRY																
10-25-84	1300	16.0	6.4	19	8.3	2.3	8.2	5.5	1.0	<0.2	<10	<0.5	3.2					
MEAN		8.5	5.6	17	9.5	3.3	8.2	5.2	1.6				4.3			124	36	1908
MEDIAN		10.0	5.7	17	10.2	2.8	7.4	5.1	1.0	<0.2	<10	<0.5	4.4			70	10	620

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Laurel Fork of North White Oak Creek, Site LN-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
01-10-83	1110	7.1	6.2	22	11.9	5.1	5.4	8.5		<0.2	<10		2.6					
01-31-83	1415	5.8	7.0	14	12.3	5.6	5.4	8.1		<0.2	<10		1.7					
03-02-83	1330	7.6	6.8	18	11.4	5.2	5.8	6.8		<0.2	<10	<0.5	1.7					
04-06-83	1230	10.1	6.5	18	11.0	3.0	5.0	6.9		<0.2	<10	<0.5	8.3					
05-04-83	1355	12.5	6.3	18	10.1	2.2	5.6	7.3	2.5	<0.2	<10	<0.5	9.5					
06-08-83	1345	16.5	7.0	20	9.3	5.4	5.0	7.4	2.5	<0.2	<10	<0.5	2.6					
07-07-83	1415	22.1	7.0	21	8.5	8.1	7.4	8.2	2.0	<0.2	<10	<0.5	2.5					
08-04-83	1335	24.9	6.9	35	8.0	7.3	5.2	9.3	1.0	<0.2	<10	<0.5	2.2					
09-12-83	1320	22.5	6.8	17	8.2	8.1	7.2	8.8	1.0	<0.2	<10	<0.5	1.5					
10-24-83	1020	13.5	5.8	24	9.4	7.0	8.9	9.7	1.5	<0.2	<10	<0.5	1.4					
11-17-83	1015	5.3	6.5	25	12.3	6.8	6.9	10.0	1.5	<0.2	<10	<0.5	2.4					
12-01-83	1105	4.9	6.8	23	11.9	4.8	4.8	8.4	1.5	<0.2	<10	<0.5	1.6					
03-08-84	1230	4.5	6.5	21	12.2	5.2	6.1	8.3	1.5	<0.2	<10	<0.5	1.0					
05-22-84	1040	17.0	6.8	19	9.1	5.2	4.8	7.0	1.5	<0.2	<10	<0.5	1.0					
07-10-84	1400	23.3		22	8.4	6.8	5.8	10.4	1.5	<0.2	<10	<0.5	1.7					
09-20-84	930	13.5	6.9	22	10.0	7.9	10.0	8.4	1.0	0.20	<10	<0.5	0.8					
10-30-84	1130	16.2	6.4	24	9.2	6.8	7.7	8.6	1.0	0.20	<10	<0.5	2.4					
MEAN		13.4	6.5	21	10.2	5.9	6.3	8.4	1.4				2.6					
MEDIAN		13.5	6.8	21	10.0	5.6	5.8	8.4	1.5	<0.2	<10	<0.5	1.7					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME   Laurel Fork of North White Oak Creek, Site LN-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-17-82	1250	5.7	6.0	33	11.4	8.3	10.0	11.2		<0.2	<10		9.0					
12-14-82	1235	4.2	5.7	20	12.3	5.1	5.6	5.9		<0.2	<10		2.6					
01-06-83	1230	6.6	6.6	17	11.7	2.9	5.3	5.4		<0.2	<10		2.7					
02-04-83	1155	5.5	6.6	13	11.8	2.5	5.3	5.5		<0.2	<10		2.7					
03-08-83	1225	11.5	6.6	23	10.3	5.2	5.4	7.5		<0.2	<10		3.5					
04-20-83	1115	7.0	6.6	18	11.7	3.6	4.8	5.2	2.5	<0.2	<10	<0.5	2.5			0	2	100
05-16-83	1130	12.3	6.4	22	10.2	4.6	4.6	6.5	2.5	<0.2	<10	<0.5	9.6					
06-09-83	1230	13.1	6.5	18	9.5	4.5	8.5	6.7	2.5	<0.2	<10	<0.5	3.6			260	40	3400
07-12-83	930	17.5	7.0	57	8.0	22.0	13.0	22.6	3.0	<0.2	<10	<0.5	6.3					
08-02-83	1105	21.4	7.2	82	7.6	38.2	14.7	43.3	5.0	<0.2	<10	<0.5	5.5			0	155	29400
09-06-83	1155	17.9	6.3	38	7.4	19.8	15.7	20.9	2.0	<0.2	<10	<0.5	5.0					
10-11-83	1445	12.2	6.2	38	7.9	15.2	13.1	15.9	1.5	<0.2	<10	<0.5	3.8			48	52	7600
11-03-83	1150	11.8	6.2	32	8.5	9.5	12.1	11.1	2.5	<0.2	<10	<0.5	3.2					
12-14-83	1105	8.4	6.8	64	10.6	7.5	6.0	11.6	2.5	<0.2	<10	<0.5	2.4			50	50	3300
01-18-84	1135	1.0	6.6	26	13.5	8.0	5.9	13.6	4.0	<0.2	<10	<0.5	1.1					
02-29-84	1100	3.5	7.0	140	11.9	8.2	6.9	16.1	36.5	<0.2	<10	<0.5	2.5			4	1	
03-19-84	1055	8.3	6.6	25	10.8	4.0	5.8	7.8	2.5	<0.2	<10	<0.5	1.5					
04-25-84	1115	11.1	7.0	37	10.2	6.6	6.2	9.4	1.0	<0.2	<10	<0.5	2.0			55	62	
05-17-84	1030	9.6	7.0	29	10.3	6.6	5.1	9.9	2.0	<0.2	<10	<0.5	2.4					
06-26-84	1050	18.0	6.5	42	7.9	19.0	10.6	20.6	3.5	<0.2	<10	<0.5	3.6			1160	140	8200
07-30-84	1350	17.6		47	8.0	25.9	14.7	28.0	1.0	<0.2	<10	<0.5	1.3					
08-23-84	1100	19.0	6.0	67	7.5	29.2	12.1	26.5	4.0	0.75	<10	<0.5	5.3			2150	590	53000
09-06-84	1045	15.0	6.9	97	8.1	38.2	16.4	39.9	4.5	1.10	<10	<0.5	1.4					
10-15-84	1050	14.3	6.9	76	8.0	29.8	18.8	31.3	4.5	1.30	<10	<0.5	3.5			20	0	
MEAN		11.4	6.4	44	9.8	13.5	9.4	15.9	4.4				3.6			375	109	15000
MEDIAN		11.5	6.6	33	10.2	8.0	6.9	11.2	2.5	<0.2	<10	<0.5	2.7			48	50	7600

* Note   mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Laurel Fork of Station Camp Creek, Site LS-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-23-82	1035	12.5	6.0	28	9.9	5.2	7.5	8.7		<0.2	<10		4.0					
01-11-83	1400		7.3	22	12.3	4.8	5.2	8.4		<0.2	<10							
02-15-83	1515	3.0	6.4	22	13.1	4.7	5.3	8.0		<0.2	<10		2.4					
03-16-83	1215	9.5	6.5	23	12.0	5.4	5.3	8.4		<0.2	<10		1.3					
04-21-83	1410	8.0	6.7	21	12.4	4.3	5.7	7.4	2.5	<0.2	<10	<0.5	1.1			0	1	8
05-05-83	1245	9.0	6.7	22	12.1	4.8	5.4	7.2	2.5	<0.2	<10	<0.5	1.6					
06-17-83	1105	18.0	6.8	25	9.9	7.0	5.6	9.2	2.5	<0.2	<10	<0.5	1.4					
07-08-83	1345	20.5	7.0	25	9.5	7.7	7.1	9.9	1.0	<0.2	<10	<0.5						
08-25-83	1045	23.5	6.6	31	8.2	9.9	8.0	11.2	1.0	<0.2	<10	<0.5	1.6					
09-08-83	1110	22.3	6.5	27	8.1	9.6	9.0	9.9	1.0	<0.2	<10	<0.5	1.8					
10-21-83	1110	15.2	6.4	20	9.2	7.7	9.7	9.9	2.0	<0.2	<10	<0.5	1.0					
11-02-83	1135	12.0	6.5	28	10.1	6.5	7.9	9.1	1.5	<0.2	<10	<0.5	0.9			36	0	2200
01-24-84	1230	0.1	6.2	23	13.9	3.8	4.2	7.7	1.0	<0.2	<10	<0.5	12.0			16	4	
03-21-84	1210	7.0	6.5	41		2.7	5.9	8.9	1.0	<0.2	<10	<0.5	5.9			70	42	
05-29-84	1400	15.1	6.8	22	9.5	6.1	7.0	7.8	1.5	<0.2	<10	<0.5	5.6			124	28	11700
08-23-84	1325	22.2	6.0	26	8.1	7.7	7.1	8.6	2.0	<0.2	<10	<0.5	1.1			320	120	22400
10-15-84	1315	16.9	7.0	39	9.0	9.3	8.4	10.8	1.5	<0.2	<10	<0.5	1.0			90	0	
MEAN		13.4	6.5	26	10.5	6.3	6.7	8.9	1.6				2.8			94	28	9077
MEDIAN		12.5	6.5	25	9.9	6.1	7.0	8.7	1.5	<0.2	<10	<0.5	1.6			70	4	2200

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Laurel Fork of Station Camp Creek, Site LS-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-17-82	1110	4.9	6.5	21	10.8	5.0	7.0	8.4		<0.2	<10		1.5					
12-14-82	1110	2.5	6.2	24	13.0	7.0	5.3	11.2		<0.2	<10		3.0					
01-06-83	1110	4.4	7.0	21	12.5	4.8	5.3	7.9		<0.2	<10		1.6					
02-04-83	1050	3.8	6.3	22	13.1	4.5	4.9	7.8		<0.2	<10		1.5					
03-09-83	1300	9.1	6.6	20	11.0	2.8	5.1	7.0		<0.2	<10		1.6					
04-20-83	1015	6.5	6.5	22	12.9	4.3	4.5	9.1	2.5	<0.2	<10	<0.5	1.1					
05-16-83	1035	12.4	6.5	21	10.0	2.5	4.1	7.0	2.5	<0.2	<10	<0.5	2.9					
06-09-83	1130	13.7	6.6	23	9.5	6.8	7.0	8.9	2.5	<0.2	<10	<0.5	1.0			17	25	990
07-12-83	1445	20.0	6.8	25	8.3	7.1	6.5	8.0	2.0	<0.2	<10	<0.5	1.5					
08-02-83	1000	20.7	6.7	24	7.8	8.2	7.4	8.4	1.0	<0.2	<10	<0.5	2.4					
08-09-83	1320															8	3	5400
09-06-83	1035	20.1	6.4	15	8.1	7.6	6.3	7.9	1.5	<0.2	<10	<0.5	2.5					
10-11-83	1110	12.4	6.4	22	9.4	6.9	8.1	10.9	1.5	<0.2	<10	<0.5	1.0			52	4	6600
11-03-83	1100	12.0	6.5	27	9.5	8.6	9.8	10.6	1.5	<0.2	<10	<0.5	1.0					
12-14-83	1015	7.5	6.4	24	11.1	3.5	4.2	9.1	2.5	<0.2	<10	<0.5	1.7			24	7	2000
01-18-84	1035	0.1	6.2	23	13.8	4.1	6.0	8.1	2.0	<0.2	<10	<0.5	0.8					
02-29-84	1145	1.7	6.8	28	13.2	3.4	5.0	8.7	2.0	<0.2	<10	<0.5	0.8			1	2	
03-19-84	1005	7.6	6.7	23	11.2	3.6	6.8	8.8	1.5	<0.2	<10	<0.5	0.9					
04-25-84	1030	8.8	6.6	19	10.9	3.7	4.4	8.3	1.5	<0.2	<10	<0.5	1.0			6	3	
05-17-84	940	8.7	6.2	23	10.9	5.0	5.8	7.9	1.5	<0.2	<10	<0.5	1.0					
06-25-84	1005	17.2	6.3	28	8.4	6.7	8.9	8.9	1.5	<0.2	<10	<0.5	1.0			300	80	4200
07-30-84	1430	17.9		33	8.5	8.8	8.6	9.3	2.0	<0.2	<10	<0.5	1.3					
08-23-84	1010	19.0	5.7	26	8.4	8.0	7.4	10.4	2.0	<0.2	<10	<0.5	1.6			690	30	15000
09-06-84	1000	14.2	6.1	24	9.1	7.9	9.2	8.2	2.0	<0.2	<10	<0.5	1.1					
10-15-84	1015	14.4	6.6	26	9.1	8.9	8.9	10.5	1.5	<0.2	<10	<0.5	1.0			70	0	
MEAN		10.8	6.4	24	10.4	5.8	6.5	8.8	1.8				1.4			130	17	5698
MEDIAN		9.1	6.5	23	10.0	5.0	6.3	8.4	1.5	<0.2	<10	<0.5	1.1			24	4	4200

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME New River, Site NR-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-22-82	1120	12.5	7.3	420	10.3	49.1	25.0	183.0		<0.2			1.2					
12-06-82	1105	13.4	7.1	190	9.9	23.4	14.6	82.6		<0.2	64		90.0					
01-13-83	1145	5.0	7.1	195	13.3	22.0	8.4	80.7		<0.2	>80		9.8					
02-01-83	1045	6.3	7.4	200	12.2	21.0	8.3	84.0		<0.2	>80		7.5					
03-03-83	1225	9.1	7.5	240	11.3	23.7	9.6	82.1		<0.2	80		4.5					
04-12-83	1415	12.0	6.9	170	11.5	18.3	8.3	67.4	2.9	<0.2	66	<0.5	25.0					
05-05-83	1305	12.5	7.4	130	10.6	15.5	7.2	51.7	2.5	<0.2	43	<0.5	33.0					
06-10-83		19.6	7.7	260	9.1	35.0	19.1	107.0	6.0	<0.2	72	<0.5	72.0					
07-05-83	1100	26.8	7.8	320	7.5	39.2	15.2	147.0	6.0	<0.2	>80	<0.5	5.9					
08-10-83	1125	27.6	7.6	435	7.3	40.9	14.8	146.0	8.5	<0.2	>80	<0.5	2.6					
09-01-83	1415	27.6	7.7	430	7.4	44.3	10.4	174.0	10.0	<0.2	>80	<0.5	1.7					
10-18-83	1125	15.5	7.0	450		41.8	12.4	165.0	8.0	<0.2	>80	<0.5	5.9					
11-07-83	1055	10.0	6.6	420	10.8	36.8	11.7	153.0	17.5	<0.2	>80	<0.5	1.0					
01-16-84	1000	2.2	7.1	195	13.5	19.1	9.9	76.6	4.0	<0.2	60	1.0	2.9					
03-15-84	1115	6.8	7.4	225	11.6	23.0	9.7	87.1	3.5	<0.2	73	<0.5	5.8					
05-21-84	945	18.9	7.6	290	9.2	31.5	11.8	115.0	4.5	<0.2	80	<0.5	2.1					
07-16-84	1100	25.1	6.5	280	7.8	37.3	11.7	120.0	3.5	0.20	>80	<0.5	19.0					
09-17-84	1030	18.8	7.6	420	8.2	49.7	7.8	164.0	12.0	<0.2	>80	<0.5	1.6					
10-19-84	1025	19.4	7.3	600	8.6	51.8	13.8	200.0	9.0	<0.2	>80	<0.5	1.5					
MEAN		15.2	7.1	309	10.0	32.8	12.1	120.3	7.0				15.4					
MEDIAN		13.4	7.4	280	9.9	35.0	11.7	115.0	6.0	<0.2	>80	<0.5	5.8					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME New River, Site NR-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-22-82	930	12.7	7.0	240	9.0	52.7	27.4	167.0		<0.2			1.8	2.28	76.6			
12-06-82	920	12.8	6.8	140	9.5	22.7	15.2	77.0		<0.2	64		85.0	7.26	2854.0			
01-13-83	835	5.0	6.8	200	13.7	22.0	10.8	81.9		<0.2	>80		13.0	3.91	670.9			
02-01-83	930	6.4	7.2	205	11.8	24.2	10.8	81.9		<0.2	>80		6.1	2.60	135.0			
03-03-83	1450	10.0	7.4	210	10.9	24.0	10.3	79.6		<0.2	80	<0.5	7.6	2.49	112.0			
04-12-83	1245	10.5	6.8	165	10.7	19.1	10.2	66.3	2.5	<0.2	62	<0.5	27.0	4.70	1138.0			
04-20-83																60	20	90
05-05-83	1115	13.1	6.9	125	9.4	15.8	8.7	52.1	2.5	<0.2	46	<0.5		5.70	1774.0			
06-10-83	930	18.7	7.6	260	8.7	32.6	16.3	122.0	4.0	<0.2	>80	<0.5	34.0	3.00	251.0			
06-13-83	1135															60	50	3150
07-05-83	915	25.5	7.5	450	6.9	39.3	15.1	157.0	6.0	<0.2	>80	<0.5	10.0	2.28	76.6			
08-10-83	1300	27.6	7.4	525	7.9	48.2	18.0	165.0	22.5	<0.2	>80	<0.5	1.8	1.80	24.0			
08-08-83	1055															5	8	4200
09-01-83	1540	26.8	7.4	450	7.1	48.0	13.5	155.0	36.0	<0.2	>80	<0.5	1.8	1.84	26.7			
10-11-83	1105															8	0	3200
10-18-83	1305	15.0	7.0	420		57.6	15.3	151.0	8.0	<0.2	>80	<0.5	19.0	2.07	47.5			
11-07-83	1300	9.9	6.8	470	10.0	42.1	10.9	172.0	23.5	<0.2	>80	0.5	2.5	2.18	61.7			
11-29-83	1110															356	232	
12-01-83	1420	6.5	6.9	278	11.2	23.0	9.3	91.0	3.5	<0.2	57	<0.5	18.0	3.75	581.9			
01-12-84	1330	1.2	7.1	260	13.5	26.5	11.5	101.7	4.0	<0.2	72	1.0	33.0	3.92	223.3			
02-08-84	1305	1.1	6.9	265	14.1	24.4	10.6	103.4	7.5	<0.2	63	2.0	2.0	2.30	79.5	0	0	400
03-15-84	1250	8.0	7.3	220	10.9	22.9	9.1	88.5	4.0	<0.2	69	<0.5		3.64	522.5			
04-11-84	1315	12.5	6.9	210	10.0	19.9	7.9	81.2	3.0	<0.2	66	<0.5	7.2	3.93	682.7	33	8	
05-21-84	1100	19.1	7.5	300	8.6	36.1	13.5	116.0	4.5	<0.2	80	<0.5	3.3	2.94	230.0			
06-07-84	1430	24.1	7.5	300	8.4	33.3	8.7	125.0	5.5	<0.2	76	<0.5	1.5	2.48	110.1			
07-16-84	1250	24.7	7.6	305	7.4	40.7	13.8	125.0	3.0	0.25	>80	<0.5	22.0	2.70	159.0			
08-29-84	1400	24.1	7.7	450	7.1	53.1	12.0	172.0	4.0	<0.2	>80	<0.5		2.02	42.1	120	0	39200
09-17-84	1145	19.5	7.5	500	7.9	46.8	14.4	200.0	6.0	<0.2	>80	<0.5	4.0	1.70	17.1			
MEAN		14.6	7.2	302	9.8	33.7	12.8	118.8	8.3				15.0	3.1	430.3	80	40	8373
MEDIAN		12.8	7.2	265	9.4	32.6	11.5	116.0	4.0	<0.2	80	<0.5	7.2	2.06	135.0	8	8	3150

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

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STATION NAME No Business Creek, Site NB-1 ✓

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
01-26-83	1450	3.5	6.9	32	13.7	10.6	5.1	13.3		<0.2	<10		2.2					
06-16-83	1235		7.4	42	9.7	15.5	7.9	17.7	2.5	<0.2	<10	<0.5	1.8					
08-15-83		22.0	7.1	39	8.8	21.1	11.1	20.7	1.0	<0.2	<10	<0.5	2.5					
02-24-84	1150	4.8	7.0	39	12.1	7.5	4.5	12.0	1.0	<0.2	<10	<0.5	1.3					
06-05-84	1500	23.0	7.2	39	8.9	13.1	7.3	15.0	1.0	<0.2	<10	<0.5	1.3					
09-04-84	1400	28.0	7.5	48	8.7	16.5	8.6	11.2	1.0	<0.2	<10	<0.5	1.8					
MEAN		13.6	7.1	40	10.3	14.1	7.4	15.0	1.3				1.8					
MEDIAN		22.0	7.1	39	8.9	13.1	7.3	13.3	1.0	<0.2	<10	<0.5	1.8					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME No Business Creek, Site NB-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
01-26-83	1305	3.0	7.1	27	13.2	7.8	5.8	11.1		<0.2	<10		2.1					
06-16-83	1200		7.3	32	9.9	10.7	7.4	12.4	2.5	<0.2	<10	<0.5	1.0					
08-15-83	1420	20.6	7.2	39	8.7	16.1	10.3	17.8	1.0	<0.2	<10	<0.5	4.3					
02-24-84	1230	6.0	6.8	28	11.6	7.0	4.5	10.4	1.0	<0.2	<10	<0.5	1.0					
06-05-84	1425	23.0	7.2	34	8.6	10.2	5.9	11.7	1.0	<0.2	<10	<0.5	1.0					
09-04-84	1330	28.0	7.4	45	8.9	18.8	8.0	17.2	1.0	<0.2	<10	<0.5	2.7					
MEAN		16.1	7.1	34	10.2	11.8	7.0	13.4	1.3				2.0					
MEDIAN		20.6	7.2	32	8.9	10.2	5.9	11.7	1.0	<0.2	<10	<0.5	1.0					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME North White Oak Creek, Site NW-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
12-15-82	1340	4.2	5.7	32	12.2	7.2	8.3	11.0		<0.2	<10		1.7					
01-13-83	1645	4.5	7.1	27	13.0	4.8	5.5	10.9		<0.2	<10		3.0					
02-01-83	1440	5.3	7.1	31	12.6	5.4	5.9	10.7		<0.2	<10		3.1					
03-03-83	1250	10.8	6.7	45	11.1	7.9	7.3	15.7		<0.2	<10		2.2					
04-12-83	945	10.0	7.0	26	11.5	5.5	6.7	9.7	2.5	<0.2	<10	<0.5	3.6					
05-06-83	1310	13.3	6.6	28	9.8	5.4	7.2	9.8	2.5	<0.2	<10	<0.5	10.0					
06-10-83	1510	20.1	7.4	32	9.2	7.3	5.4	10.6	2.5	<0.2	<10	<0.5	1.5					
07-05-83	1450	25.3	7.5	32	8.3	8.6	7.8	11.8	2.5	<0.2	<10	<0.5	4.3					
08-10-83	1505	28.1	7.4	38	8.1	11.5	5.5	12.8	2.0	<0.2	<10	<0.5	1.5					
09-06-83	1035	23.0	5.7	37	7.9	11.9	5.5	13.2	1.5	<0.2	<10	<0.5	1.4					
10-17-83	1230	13.5	6.9	36	10.2	9.1	6.9	12.6	2.0	<0.2	<10	<0.5	2.8					
01-23-84	1130	0.1	6.6	37	14.1	5.9	6.0	12.3	3.0	<0.2	<10	<0.5	1.2					
04-06-84	1000	8.2	6.5	34	11.5	4.3	6.9	11.1	1.5	<0.2	<10	<0.5	3.7					
05-18-84	1405	16.0	6.6	29	9.6	5.3	5.7	10.0	1.5	<0.2	<10	<0.5	2.0					
07-06-84	1020		7.1	26	8.6	8.6	10.2	14.2	1.5	0.25			13.0					
08-27-84	1050	21.3	7.0	42	8.6	11.9	7.8	13.9	2.5	<0.2	<10	<0.5	1.0					
10-25-84	1015	16.0	6.1	37	9.3	7.4	8.1	12.7	2.5	<0.2	<10	<0.5	3.9					
MEAN		13.7	6.4	33	10.3	7.5	6.9	11.9	2.2				3.5					
MEDIAN		13.3	6.9	32	9.8	7.3	6.9	11.8	2.5	<0.2	<10	<0.5	2.8					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

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STATION NAME North White Oak Creek, Site NW-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-09-82	1305	7.4	7.0	34	10.5	9.4	12.8	13.7		<0.2			1.2					
12-07-82	1235	10.9	6.0	37	10.2	8.0	7.9	14.4		<0.2	<10		4.3					
01-03-83	1235	7.3	6.3	36	11.5	8.4	8.5	13.5		<0.2	<10		4.6					
01-31-83	1305	5.5	6.9	26	12.1	5.6	5.4	12.5		<0.2	<10		2.6					
03-02-83	1220	7.8	6.9	34	11.4	5.6	5.2	11.6		<0.2	<10	<0.5	2.6					
04-06-83	1130	9.9	6.6	34	10.5	5.1	7.3	11.3		<0.2	<10	<0.5	13.0					
04-20-83																50	20	170
05-04-83	1245	12.8	6.7	30	9.4	7.0	7.3	12.3	2.2	<0.2	<10	<0.5	32.0					
06-08-83	1240	16.5	6.9	36	9.0	7.8	5.2	11.8	2.5	<0.2	<10	<0.5	2.9					
06-13-83	1020															180	40	4900
07-07-83	1300	20.7	7.0	37	8.4	9.9	8.2	14.6	2.5	<0.2	<10	<0.5	3.6					
08-04-83	1240	23.8	7.1	40	8.7	11.6	7.0	16.5	2.0	<0.2	<10	<0.5	2.6					
08-08-83	950															1	6	18600
09-12-83	1210	21.5	6.3	34	8.3	9.7	10.4	14.1	2.0	<0.2	<10	<0.5	2.2					
10-11-83	1000															60	8	5000
10-24-83	1110	14.0	5.9	38	9.2	8.9	9.3	15.0	2.5	<0.2	<10	<0.5	2.6					
11-17-83	1050	5.9	6.2	38	11.5	11.1	8.0	15.2	2.0	<0.2	<10	<0.5	2.5					
11-29-83	1005															316	108	
12-02-83	1155	6.7	6.7	42	10.7	6.0	7.4	15.6	2.5	<0.2	<10	<0.5	6.0					
01-12-84	1200	0.6	6.4	47		6.5	6.5	12.2	2.0	<0.2	<10	<0.5	3.2					
02-08-84	1150	0.0	6.6	42	13.5	5.2	7.9	14.0	2.5	<0.2	<10	<0.5	1.8			0	0	1200
03-08-84	1130	4.8	6.7	38	11.8	6.1	5.8	12.6	2.0	<0.2	<10	<0.5	2.1					
04-11-84	1130	11.1	6.8	38	10.2	5.5	7.3	12.6	2.0	<0.2	<10	<0.5	2.7			0	1	10
06-07-84	1215	19.0	7.1	41	9.2	10.5	6.8	14.7	2.0	<0.2	<10	<0.5	1.8					
07-10-84	1310	21.1		39	8.3	10.8	7.8	17.0	2.0	<0.2	<10	<0.5	3.6			20	20	9600
08-29-84	1135	19.2	7.0	59	8.4	11.9	10.2	15.8	2.0	0.40	<10	<0.5	6.7			2660	180	55200
09-20-84	1015	12.6	7.1	35	9.1	9.2	9.9	13.5	2.0	0.35	<10	<0.5	2.0					
10-30-84	1250	16.7	6.9	42	9.3	9.9	8.3	21.8	2.0	0.45	<10	<0.5	2.4			50	40	
MEAN		12.0	6.6	38	10.1	8.2	7.8	14.2	2.2				4.7			334	42	11835
MEDIAN		11.1	6.7	38	9.4	8.4	7.8	14.0	2.0	<0.2	<10	<0.5	2.6			50	20	4900

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Pine Creek, Site PI-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-22-82	1415	10.7	7.5	165	11.1	50.5	22.2	61.2		<0.2			0.8					
12-06-82	1440	11.3	6.9	88	10.6	25.5	10.4	33.7		<0.2	10		10.0					
01-13-83	1730	4.3	7.5	100	13.2	21.7	8.1	32.3		<0.2	11		6.7					
02-01-83	1350	5.8	7.6	95	13.0	24.8	8.1	36.9		<0.2	10		4.3					
03-03-83	1635	9.4	8.1	83	11.8	23.8	7.4	32.6		<0.2	<10		3.4					
04-12-83	1045	9.0	7.2	78	12.4	22.1	11.5	31.3	2.5	<0.2	<10	<0.5	7.0					
05-06-83	1145	13.2	7.6	68	10.0	18.8	9.6	27.2	4.0	<0.2	<10	<0.5	13.0					
06-10-83	1630	17.7	7.8	110	9.2	33.1	10.3	40.6	4.5	<0.2	10	<0.5	7.9					
07-05-83	1515	22.9	7.8	105	8.6	46.7	14.6	53.5	9.5	<0.2	15	<0.5	34.0					
08-19-83	1110	21.5	7.8	235	8.5	66.6	17.5	66.0	16.0	<0.2	13	<0.5	1.2					
09-06-83	1130	21.5	7.0	220	7.6	64.3	15.3	69.0	12.0	<0.2	18	<0.5	1.5					
10-17-83	1400	12.6	7.7	220	10.3	60.2	16.3	89.2	7.0	<0.2	23	<0.5	6.6					
11-07-83	1430	8.6	7.1	325	12.7	69.3	16.2	95.0	17.5	<0.2	36	<0.5	1.2					
11-30-83	1040	5.3	6.2	103	12.4	26.9	11.8	43.0	5.5	<0.2	14	<0.5	7.0					
01-16-84	1350	2.8	7.2	88	13.2	22.6	7.6	35.4	4.0	<0.2	13	<0.5	2.8					
02-16-84	910	6.4	7.4	73	11.9	18.0	8.4	29.4	2.5	<0.2	11	<0.5	14.0					
03-26-84	1400	9.2	7.1	81	11.3	19.1	11.7	30.7	3.0	<0.2	11	<0.5	5.7					
05-21-84	1210	17.1	7.6	106	10.0	31.3	12.0	41.0	4.5	<0.2	12	<0.5	3.5					
07-06-84	1130	20.0	7.6	70	8.2	36.8	12.4	40.6	5.5	<0.2	<10	<0.5	3.8					
08-27-84	1225	20.2	6.8	186	9.0	63.5	18.4	66.0	8.0	<0.2	16	<0.5	2.3					
09-17-84	1255	15.8	7.5	235	10.2	69.5	19.5	65.0	14.0	<0.2	13	<0.5	1.1					
10-25-84	1115	16.6	6.4	131	9.6	37.8	13.8	52.0	5.0	<0.2	13	<0.5	6.6					
MEAN		12.8	7.0	135	10.7	38.8	12.9	48.7	7.4				6.6					
MEDIAN		11.3	7.5	103	10.3	31.3	11.8	40.6	5.5	<0.2	11	<0.5	4.3					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Pine Creek, Site PI-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-22-82	1450	9.2	7.2	235	9.0	74.6	32.9	84.5		<0.2			2.1					
12-06-82	1400	11.5	7.0	100	10.6	31.0	13.3	40.0		<0.2	12		11.0					
01-13-83	1550	4.3	7.2	40	13.2	25.3	9.6	37.3		<0.2	11		7.2					
02-01-83	1320	5.8	7.7	115	13.1	30.5	10.8	42.5		<0.2	12		6.7					
03-03-83	1555	11.0	7.2	120	13.8	31.5	9.1	41.5		<0.2	12		5.2					
04-12-83	1130	9.5	7.1	90	11.8	27.1	10.2	37.6	5.0	<0.2	15	<0.5	6.7					
04-18-83																1780	148	840
05-06-83	1110	12.7	7.1	78	10.1	22.5	7.7	31.2	4.0	<0.2	<10	<0.5	13.0					
06-09-83	1335															1540	140	6080
07-05-83	1320	22.2	7.8	230	7.9	65.8	23.9	77.2	11.5	0.20	24	<0.5	25.0					
08-08-83	1130															60	40	34400
08-19-83	1015	20.7	7.3	290	6.4	75.4	21.3	88.9	16.0	<0.2	28	<0.5	1.8					
09-06-83	1230	21.3	7.0	300	6.5	80.9	14.6	97.0	17.0	<0.2	27	<0.5	1.5					
10-11-83	1145															56	172	67200
10-17-83	1445	12.7	7.4	295	8.4	79.1	20.1	117.3	9.0	<0.2	30	<0.5	6.0					
11-07-83	1515	7.3	6.9	270	10.8	72.4	18.6	168.0	10.5	<0.2	28	<0.5	1.5					
11-29-83	1150															776	352	
11-30-83	1120	4.8	7.0	122	11.9	31.8	10.3	52.0	5.0	<0.2	14	<0.5	7.9					
01-16-84	1445	2.9	7.1	100	13.8	28.0	11.1	41.4	5.5	<0.2	14	<0.5	3.6					
02-16-84	950	6.0	6.5	60	11.9	20.4	9.5	32.5	3.0	<0.2	12	<0.5	15.0			43	385	
03-26-84	1430	9.3		89	11.8	22.2	10.7	35.9	3.0	<0.2	14	<0.5	6.4			356	92	
05-21-84	1235	17.1	7.7	141	9.2	41.6	12.4	53.0	6.0	<0.2	15	<0.5	2.8			292	68	7300
06-29-84	1045	19.8	7.5	180	7.1	55.7	23.5	58.0	9.0	<0.2	16	<0.5	2.6			280	80	15600
07-16-84						58.3	20.8	73.0	7.5	<0.2	12	<0.5	7.8					
08-27-84	1305	19.3	6.8	325	7.9	86.1	23.5	95.0	20.0	<0.2	38	<0.5	5.5			100	60	
09-17-84	1320	14.9	7.4	360	7.7	94.0	27.0	95.0	23.0	<0.2	41	<0.5	3.4					
10-25-84	1205	16.9	6.7	160	9.1	46.7	13.1	62.0	5.0	<0.2	20	<0.5	5.0					
MEAN		12.3	7.2	176	10.1	50.0	16.1	66.4	9.4				6.7			528	154	21903
MEDIAN		11.5	7.1	141	10.1	41.6	13.1	53.0	7.5	<0.2	15	<0.5	5.5			280	92	7300

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

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STATION NAME Puncheoncamp Fork of Williams Creek, Site PU-1

DATE	TIME	TEMP	pH	COND	DO	ALK	ACID	HARD	Cl-	Fe	SO4	Mn	TURB	STAGE	STREAM	T COL	F COL	F STRP
				umhos											FLOW	#/	#/	#/
	hours	C		/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	NTU	ft	cfs	100ml	100ml	100ml
11-01-82	1330	12.3	7.2	65	9.2													
12-10-82	1115	5.9	6.2	61	12.4	7.0	8.9	25.2		<0.2	19		3.0					
01-04-83	1045	3.6	5.9	58	13.4	5.6	5.3	22.5		<0.2	25		3.0					
02-22-83	1000	6.1	6.9	60	12.2	5.0	5.1	22.6		<0.2	22		1.5					
03-23-83	935	4.1	6.4	78	13.5	5.3	6.7	32.6		<0.2	36		3.5					
04-22-83	950	7.9	6.9	51	12.2	4.9	5.4	23.2	2.5	<0.2	17	<0.5	2.8					
05-12-83	1020	13.2	6.9	45	10.1	6.0	6.9	17.8	2.5	<0.2	14	<0.5	3.5					
06-13-83	1015	15.7	7.1	48	9.4	9.3	8.1	18.4	2.5	<0.2	14	<0.5	3.0					
07-11-83	1125	19.6	7.3	65	8.8	17.8	7.8	27.6	2.5	<0.2	10	<0.5	5.1					
08-08-83	1000	21.2	7.2	62	7.6	18.7	10.0	21.9	3.5	<0.2	<10	<0.5	1.6					
09-14-83	1010	18.1	7.0	43	8.7	21.8	7.2	24.8	3.5	<0.2	<10	<0.5	1.9					
10-24-83	1030	13.7	6.8	80	8.7	13.1	10.3	32.0	1.5	<0.5	17	<0.5	1.4					
11-11-83	1040	7.3	5.9	85	11.1	10.5	7.7	36.0	2.5	<0.2	21	<0.5	0.6					
12-13-83	1000	7.8	6.1	48	11.3	5.3	5.9	30.2	2.0	<0.2	28	<0.5	2.0					
02-17-84	1015	6.8	6.6	56	11.8	4.0	5.8	21.2	1.5	<0.2	16	<0.5	3.1					
03-13-84	950	3.9	6.6	52	12.5	4.6	5.2	21.4	1.5	<0.2	17	<0.5	3.0					
04-04-84	1045	9.2	7.0	53	11.1	7.2	6.9	20.6	1.0	<0.2	15	<0.5	43.0					
05-16-84	1220	11.7	7.0	58	10.2	5.8	6.5	21.8	1.0	<0.2	13	<0.5						
06-27-84	1020	12.6	7.0	56	9.0	13.1	9.8	21.1	3.0	<0.2	<10	<0.5	1.9					
07-23-84	1150	19.9	6.3	57	8.5	16.3	9.2	21.8	25.0	<0.2	<10	<0.5	1.2					
08-21-84	1035	18.6	6.3		8.8	16.0	11.2	26.2	2.5	<0.2	12	<0.5	1.1					
10-11-84	1125	14.1	6.1	112	9.4	11.9	13.6	44.0	3.0	<0.2	35	<0.5	5.4					
MEAN		11.5	6.4	62	10.5	9.5	7.8	25.4	3.6				4.6					
MEDIAN		11.1	6.8	58	10.1	7.2	7.2	22.6	2.5	<0.2	16	<0.5	2.8					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Puncheoncamp Fork of Williams Creek, Site PU-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-01-82	1255	13.8	6.9	120	7.1													
12-10-82	1400	6.4	6.3	83	11.9	7.1	14.2	29.6		<0.2	30		2.5					
01-04-83	1250	4.0	5.9	86	12.6	5.8	7.8	38.7		<0.2	42		3.4					
02-22-83	1130	7.2	6.6	90	11.4	3.9	5.3	37.0		<0.2	40		5.2					
03-23-83	1230	4.7	6.4	90	13.1	5.0	5.6	39.7		<0.2	46		4.7					
04-22-83	1120	8.6	6.7	85	11.4	5.1	5.1	27.3	2.5	<0.2	26	0.8	2.5			16	0	10
05-17-83	1415	13.0	6.5	65	10.2	6.3	4.8	23.5	2.5	<0.2	23	<0.5	4.0					
06-13-83	1510	16.5	6.9	67	9.3	10.6	8.2	28.1	2.5	<0.2	21	<0.5	3.3			210	70	9850
07-11-83	1440	19.5	7.0	130	8.2	19.1	9.6	53.6	2.5	<0.2	44	<0.5	3.6					
08-08-83	1410	23.4	6.8	72	7.3	22.2	11.7	29.0	4.0	<0.2	<10	<0.5	2.8			0	76	36000
09-14-83	1255	18.3	7.0	90	7.3	36.7	8.7	39.7	3.5	<0.2	<10	<0.5	3.0					
10-25-83	1535	13.2	6.3	350	8.3	6.9	13.0	180.5	2.5	<0.2	18	<0.5	1.2			224	24	21000
11-11-83	1140	7.2	6.3	180	10.1	9.5	11.4	87.1	3.5	<0.2	79	<0.5	0.9					
12-13-83	1135	7.8	6.3	88	11.3	5.5	5.8	37.0	2.5	<0.2	32	1.5	2.7			24	0	2800
02-17-84	1140	7.1	6.3	81	11.4	3.4	7.5	29.1	1.5	<0.2	16	<0.5	5.0					
03-13-84	1040	5.4	6.4	113	12.0	4.3	6.9	48.2	1.5	<0.2	46	1.6	27.0					
04-04-84	1200	9.6	8.1	112	10.6	3.4	6.7	43.2	1.0	<0.2	27	1.5	70.0			190	42	
05-16-84	1420	12.8	6.8	80	10.3	5.3	6.8	20.5	2.0	<0.2	29	<0.5						
06-27-84	1105	17.3	6.9	87	8.0	24.9	13.8	35.3	3.0	0.41	13	<0.5	17.0			30	20	20200
07-23-84	1335	18.5	6.4	105	8.3	21.1	15.8	37.9	3.0	0.35	17	<0.5	2.7					
08-21-84	1220	19.3	6.5		8.0	26.1	11.0	41.0	2.5	0.40	20	<0.5	2.5					
10-11-84	1315	15.4	6.6	380	7.5	12.9	16.2	148.0	9.5	0.20	>80	<0.5	2.4			80	0	9600
MEAN		12.2	6.4	122	9.8	11.7	9.3	50.2	2.9				8.3			97	29	14209
MEDIAN		12.8	6.5	90	10.1	6.9	8.2	37.9	2.5	<0.2	27	<0.5	3.0			30	20	9850

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

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STATION NAME Roaring Paunch Creek, Site RP-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-27-82	1345	9.2	7.2	200	11.1	16.7	15.5	90.0		0.27			5.5					
12-07-82	910	10.0		102	11.7	15.6	10.0	38.8		<0.2	32		22.0					
01-08-83	930	8.0	6.8		13.2	9.1	8.6	48.4		<0.2	52		6.3					
01-30-83	1020	8.0	6.7	90	12.4	10.8	8.3	31.6		<0.2	28		8.3					
03-02-83	1125	8.0	6.8	90	13.1	9.6	8.0	31.9		<0.2	30	<0.5	4.4					
04-19-83	1050	7.5	7.1	78	12.7	9.8	7.8	31.0	3.5	<0.2	23	<0.5	6.5					
05-17-83	1515	13.6	7.0	72	10.2	2.6	12.2	27.6	4.0	0.35	33	<0.5	32.0			640	180	1860
06-14-83	1435	21.0	7.0		9.8	13.7	9.7	50.8	7.0	<0.2	50	<0.5	4.8					
07-06-83	1055	21.1	7.1	185	8.3	14.0	9.6	73.3	3.5	<0.2	67	<0.5	84.0			0	5560	
08-16-83	1330	23.0	6.4	700		18.2	16.4	140.0	127.0	<0.2	>80	<0.5	12.0			0	4	5200
09-09-83	1040	22.2	7.0	400	7.2	33.1	15.7	103.0	19.0	<0.2	>80	0.8	3.4					
10-03-83	1200	16.2	7.0	550	7.8	29.1	7.9	69.5	7.0	<0.2	58	1.3	4.0			30	5	18400
11-01-83	1120	11.8	6.9	730	10.0	23.5	16.8	185.0	32.0	<0.2	>80	1.3	1.3					
12-05-83	1115	9.1	6.7	89	11.2	10.0	7.9	33.8	4.0	<0.2	17	<0.5	18.0			64	696	
01-09-84	1200	0.3	6.2	82	13.6	9.6	7.3	43.4	7.5	<0.2	30	<0.5	4.2					
02-14-84	1115	8.6	6.8	69	11.3	8.3	9.9	23.9	3.5	<0.2	18	<0.5	67.0			83	358	
03-06-84	1115	5.8	7.3	102	12.1	10.4	7.7	37.9	5.0	<0.2	29	<0.5	14.0					
04-02-84	1120	8.1	6.8	144	11.5	8.0	6.4	46.1	3.0	0.45	48	<0.5	7.6			17	6	
05-15-84	1240	15.1	6.9	128	9.6	10.1	7.1	49.1	3.0	<0.2	44	<0.5						
06-04-84	1105	18.8	7.1	168	9.1	18.6	10.1	56.0	10.0	<0.2	40	<0.5	5.0			300	20	7600
07-12-84	1155	22.8	6.9	230	7.7	23.1	11.1	71.0	29.5	0.60	47	<0.5	3.4					
09-05-84	1120	19.2	7.0	275	8.5	30.3	15.3	120.0	127.0	0.55	66	<0.5	4.1					
10-09-84	1205	15.4		1200	9.1	20.1	15.5	194.0	321.4	0.60	>80	<0.5	3.8			1080	160	28314
MEAN		13.2	6.8	271	10.5	15.3	10.6	68.5	39.8				14.6			246	777	12275
MEDIAN		11.8	6.9	144	10.2	13.7	9.7	49.1	7.0	<0.2	44	<0.5	5.5			64	160	7600

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Roaring Paunch Creek, RP-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-27-82	1300	8.0	7.3	200	10.2	27.3	13.1	93.0		<0.2			1.0					
12-07-82	950	10.0		90	11.5	15.2	12.9	33.8		<0.2	25		12.0					
01-08-83	1015	8.0	6.7		13.2	11.5	8.0	51.5		<0.2	52		3.7					
01-30-83	1110	7.5	6.6	90	12.0	12.8	7.9	36.0		<0.2	31		8.4					
03-02-83	1200	8.5	7.0	95	12.9	11.7	7.8	34.0		<0.2	35	<0.5	5.0					
04-19-83	1200	7.3	6.9	88	12.9	12.4	6.6	34.7	4.0	<0.2	27	<0.5	9.7					
05-17-83	1550	13.2	7.0	75	10.2	10.9	7.1	26.7	4.0	<0.2	20	<0.5	27.0			880	240	3060
06-14-83	1510	22.0	7.0		9.7	14.4	9.2	59.9	3.0	<0.2	57	<0.5	4.5					
07-06-83	1130	20.5	7.2	170	7.8	20.4	9.6	68.6	3.5	<0.2	59	<0.5	35.0			0	2210	
08-16-83	1405	21.0	7.2	180		39.0	18.7	79.8	2.0	<0.2	53	<0.5	2.5			12	5	9200
09-09-83	1125	20.0	7.2	185	5.1	57.1	19.0	80.0	3.0	<0.2	22	<0.5	1.2					
10-03-83	1125	14.5	7.0	160	6.5	60.5	14.6	104.4	76.0	<0.2	70	<0.5	1.0			55	0	21000
11-01-83	1155	10.1	6.7	222	10.0	22.9	12.7	130.0	4.5	<0.2	>80	<0.5	0.6					
12-05-83	1155	9.0	6.8	95	10.7	11.4	8.1	34.7	4.0	<0.2	21	<0.5	14.0			316	316	
01-09-84	1100	1.9	6.0	119	13.2	10.8	6.7	46.2	6.0	<0.2	38	<0.5	3.2					
02-14-84	1030	8.1	6.6	66	11.4	8.2	10.3	23.9	2.5	<0.2	19	<0.5	53.0			24	20	
03-06-84	1035	5.8	7.4	101	12.2	10.3	7.3	34.9	4.5	<0.2	28	<0.5	7.8					
04-02-84	1210	7.7	7.1	90	11.9	9.4	7.0	36.2	2.5	<0.2	26	<0.5	6.3			49	35	
05-15-84	1110	13.5	6.7	130	9.7	12.2	8.1	54.2	3.0	<0.2	45	<0.5						
06-04-84	1140	17.9	7.1	190	8.5	19.0	10.9	63.0	10.0	<0.2	45	<0.5	5.6			140	20	8000
07-12-84	1050	21.6	6.5	215	7.1	26.7	11.2	70.0	16.5	0.25	45	<0.5	17.0					
09-05-84	1045	16.6	7.0	400	7.0	43.6	14.4	105.0	66.0	<0.2	47	<0.5	1.6					
10-09-84	1125	14.0		195	7.4	52.0	22.8	70.0	15.7	0.45	15	<0.5	45.0			5700	2500	93236
MEAN		12.5	6.8	150	10.1	22.6	11.0	59.6	12.1				12.1			797	594	22416
MEDIAN		10.1	7.0	130	10.2	14.4	9.6	54.2	4.0	<0.2	35	<0.5	5.6			55	35	9200

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Rock Creek, Site RO-1

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
10-27-82	1200	8.8	6.9	210	11.2	25.5	13.1	100.0		<0.2			7.6					
12-07-82	1220	10.0		80	11.7	11.5	10.3	30.7		<0.2	26		11.0					
01-08-83	1245	7.5	6.5		12.5	8.2	11.5	46.2		0.85	57		7.6					
01-30-83	1245	8.0	6.1	110	12.2	8.7	11.0	39.6		0.80	45		12.0					
03-02-83	1230	8.0	6.1	110	11.9	9.0	10.8	38.5		0.90	50		8.5					
04-19-83	1250	8.7	6.5	85	12.2	9.3	7.1	32.4	2.8	0.80	32	<0.5	6.8					
05-17-83	1630	13.3	6.5	60	10.5	7.0	8.3	24.1	2.5	0.25	22	<0.5	17.0			70	0	40
06-14-83	1540	21.0	6.7		9.6	7.9	11.4	65.3	2.5	1.50	77	<0.5	16.0					
07-06-83	1220	21.2	7.4	145	8.2	28.8	14.2	58.2	2.5	0.65	42	<0.5	34.0			0	516	
08-16-83	1445	24.0	7.6	240		27.6	15.5	103.7	3.5	<0.2	>80	0.6	5.8			0	1	10200
09-09-83	1200	22.3	7.2	310	8.7	26.9	11.9	106.0	3.5	<0.2	74	0.8	2.2					
10-03-83	1005	14.5	6.7	220	9.3	33.6	11.9	105.0	3.0	<0.2	76	1.5	3.8			15	10	2800
11-01-83	1305	13.4	7.0	240	10.0	23.4	13.5	91.7	2.5	<0.2	70	1.3	6.6					
12-05-83	1250	9.3	6.3	81	11.5	5.7	8.0	29.1	1.5	0.20	25	<0.5	12.0			4	0	
01-09-84	1005	2.2	6.0	110	13.2	7.5	9.6	43.9	1.5	0.20	45	1.0	5.9					
02-14-84	945	7.6	6.0	58	11.8	3.8	9.7	20.0	1.0	<0.2	17	1.2	28.0			4	0	800
03-06-84	1000	5.6	6.5	68	12.0	7.0	9.2	28.8	2.0	0.45	25	<0.5	8.3					
04-02-84	1245	8.9	6.1	88	11.2	4.0	9.7	31.5	1.5	1.60	34	<0.5	7.6			1	0	
05-15-84		Lake Cumberland Backed-up Beyond This Site																
06-04-84		Lake Cumberland Backed-up Beyond This Site																
07-12-84	1005	22.5	5.7	242	8.4	4.4	12.2	75.0	1.5	1.90	>80	<0.5	6.0					
08-13-84	1210	22.6	6.4	175	8.5	32.7	12.5	78.2	1.5	0.35	55	<0.5	6.2			180	0	1400
09-05-84	1015	18.4	7.2	285	9.2	33.6	13.0	102.0	2.5	0.55	80	<0.5	5.8					
10-09-84	1020	15.8	5.4	375	9.1	3.2	24.7		3.0	>2.0	>80	1.0	33.0			0	0	4290
MEAN		12.2	6.3	165	10.6	15.0	11.8	59.5	2.3				11.4			30	59	3255
MEDIAN		10.0	6.5	110	11.2	8.7	11.4	46.2	2.5	0.25	50	<0.5	7.6			4	0	1400

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Rock Creek, Site RO-3

DATE	TIME	TEMP	pH	COND	DO	ALK	ACID	HARD	Cl-	Fe	SO4	Mn	TURB	STAGE	STREAM	T COL	F COL	F STRP
				umhos											FLOW	#/	#/	#/
	hours	C		/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	NTU	ft	cfs	100ml	100ml	100ml
11-17-82	1345	4.9	6.3	18	11.9	3.0	7.2	5.4		<0.2	<10		1.1					
12-14-82	1315	2.5	5.6	17	12.5	4.6	5.6	5.7		<0.2	<10		1.5					
01-06-83	1310	5.4	5.9	18	12.2	2.3	7.0	5.5		<0.2	<10		0.9					
02-04-83	1245	4.4	6.0	18	12.6	2.7	5.3	5.1		<0.2	<10		1.1					
03-08-83	1300	11.6	6.0	17	10.4	3.0	5.0	4.6		<0.2	<10		0.9					
04-20-83	1155	6.5	5.7	17	12.8	2.3	4.8	7.0	2.5	<0.2	<10	<0.5	0.9			0	0	0
05-16-83	1215	11.7	5.4	21	10.4	2.5	5.6	7.0	2.5	<0.2	<10	<0.5	4.6					
06-09-83	1320	13.6	6.0	17	9.6	2.9	4.8	5.0	2.5	<0.2	<10	<0.5	0.6			10	8	690
07-12-83		18.6	5.6	15	8.5	3.1	7.3	4.7	1.5	<0.2	<10	<0.5	1.0					
08-02-83	1135	21.1	6.2	15	7.5	2.5	8.1	5.2	1.0	<0.2	<10	<0.5	4.6			0	281	33400
09-06-83	1230	20.2	6.0	12	7.9	3.4	6.9	5.3	1.5	<0.2	<10	<0.5	1.5					
10-01-83	1225	12.3	6.1	15	9.3	4.3	4.9	4.5	1.5	<0.2	<10	<0.5	1.1			32	0	7800
11-03-83	1230	12.7	6.1	15	9.4	5.3	9.5	4.5	2.0	<0.2	<10	<0.5	1.0					
12-14-83	1145	7.8	5.3	20	11.1	1.9	5.2	6.4	2.5	<0.2	<10	<0.5	0.5			14	2	1200
01-18-84	1240	0.3	5.6	18	13.5	5.9	6.0	12.3	3.0	<0.2	<10	<0.5	1.2					
02-29-84	1010	1.9	6.0	19	13.1	2.0	5.3	6.5	1.5	<0.2	<10	<0.5	0.7			3	0	
03-19-84	1125	8.0	6.1	20	10.9	2.2	4.7	6.8	1.5	<0.2	<10	<0.5	0.7					
04-25-84	1140	9.5	6.0	20	10.8	2.3	5.1	7.2	1.5	<0.2	<10	<0.5	0.6			3	0	
05-17-84	1055	8.8	5.7	22	11.4	3.4	5.8	7.1	1.5	<0.2	<10	<0.5	0.5					
06-26-84	1115	17.4	5.8	16	8.3	2.9	6.8	6.7	2.0	<0.2	<10	<0.5	2.3			500	20	2200
07-30-84	1330	17.6		17	9.1	4.5	7.5	4.2	3.5	0.75	<10	<0.5	4.8					
08-23-84	1140	19.5	5.4	17	8.1	4.6	7.1	5.6	1.5	0.20	<10	<0.5	1.1			10	190	17600
09-06-84	1115	14.2	5.8	16	9.2	4.0	6.9	5.2	1.5	<0.2	<10	<0.5	1.0					
10-15-84	1130	14.4	6.5	18	8.8	4.9	7.0	6.7	1.5	0.25	<10	<0.5	1.0			490	0	
MEAN		11.0	5.8	17	10.4	3.4	6.2	6.0	1.9				1.5			106	50	8984
MEDIAN		11.6	6.0	17	10.4	3.0	5.8	5.5	1.5	<0.2	<10	<0.5	1.0			10	0	2200

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Station Camp Creek, Site SC-1

DATE	TIME	TEMP	pH	COND	DO	ALK	ACID	HARD	Cl-	Fe	SO4	Mn	TURB	STAGE	STREAM	T COL	F COL	F STRP
				umhos											FLOW	#/	#/	#/
	hours	C		/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	NTU	ft	cfs	100ml	100ml	100ml
11-23-82	1310	13.5	6.3	35	9.7	11.3	9.6	13.7		<0.2	<10		3.8					
01-11-83	1330		7.5	30	12.2	7.4	5.0	10.4		<0.2	<10		3.0					
02-15-83	1445	3.0	6.9	34	13.3	8.1	6.9	13.2		<0.2	<10		2.8					
03-16-83	1150	10.5	7.0	27	12.2	7.8	5.1	10.0		<0.2	<10							
04-21-83	1345	8.0	6.8	23	12.1	5.0	5.0	9.9	2.5	<0.2	<10	<0.5	1.7			4	0	4
05-05-83	1225	9.0	6.7	29	11.9	5.2	5.0	10.1	2.5	<0.2	<10	<0.5	1.9					
06-17-83	1120	18.5	7.2	37	9.9	12.9	7.9	16.0	2.5	<0.2	<10	<0.5	1.4					
07-08-83	1400	21.0	7.3	40	9.5	13.2	7.6	15.3	1.0	<0.2	<10	<0.5	2.0					
08-25-83	1100	23.5	6.9	42	8.4	15.5	10.9	17.1	1.0	<0.2	<10	<0.5	1.4					
09-08-83	1215	23.0	6.8	44	8.1	17.5	7.7	17.6	1.0	<0.2	<10	<0.5	1.1					
10-21-83	1135	15.5	6.6	40	9.0	14.9	8.5	15.9	1.5	<0.2	<10	<0.5	3.7					
MEAN		14.6	6.8	32	9.7	9.9	6.6	12.4	1.5				2.3					
MEDIAN		13.5	6.9	35	9.9	11.3	7.6	13.7	1.5	<0.2	<10	<0.5	1.9					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Station Camp Creek, Site SC-2

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-02-83	1110	12.5	6.9	55	10.0	21.5	11.5	23.0	1.0	<0.2	<10	<0.5	1.0			20	4	3600
01-24-84	1210	0.1	6.6	42	13.9	12.0	7.9	18.2	1.0	<0.2	<10	<0.2	24.0			3	37	
03-21-83	1215	7.0	7.1	38		9.2	6.9	14.6	1.0	<0.2	<10	<0.2	8.1			9	8	
05-29-84	1420	14.6	7.5	56	9.6	19.8	9.3	23.7	1.0	<0.2	<10	<0.5	3.7			124	28	11700
08-23-84	1315	22.0	6.5	56	7.7	23.8	4.7	23.2	1.0	<0.2	<10	<0.5	1.6			390	40	24000
10-15-84	1305	16.6	7.3	57	8.7	21.6	9.9	22.5	1.0	<0.2	<10	<0.5	1.0			60	0	
MEAN		12.1	6.8	51	10.0	18.0	8.4	20.9	1.0				6.6			101	20	13100
MEDIAN		14.6	6.9	55	9.6	19.8	7.9	22.5	1.0	<0.2	<10	<0.5	1.6			20	8	11700

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Station Camp Creek, Site SC-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-18-82	1015	8.6	6.5	50	11.2	21.5	14.7	22.6		<0.2	<10		3.0					
12-14-82	1425	5.2	6.2	51	11.8	23.4	10.9	27.0		<0.2	<10		3.1					
01-06-83	1435	6.3	7.3	54	11.7	23.0	7.5	26.9		<0.2	<10		3.5					
02-04-83	1355	4.5	7.0	34	12.8	11.6	7.4	15.3		<0.2	<10		3.4					
03-09-83	1145	9.0	7.3	38	11.3	15.4	8.1	18.8		<0.2	<10		2.5					
04-21-83	1300	9.0	7.4	42	11.7	13.9	6.8	18.8	2.5	<0.2	<10	<0.5	2.3			0	1	8
05-16-83	1335	12.1	8.6	31	10.0	8.9	5.0	14.0	2.5	<0.2	<10	<0.5	8.4					
06-09-83	1500	16.7	7.6	51	9.2	19.0	8.2	23.8	2.5	<0.2	<10	<0.5	2.2			8	21	870
07-12-83	1140	20.1	7.0	60	8.9	26.1	11.3	27.4	1.5	<0.2	<10	<0.5	2.3					
08-02-83	1230	22.3	7.5	65	8.1	29.5	9.1	30.4	1.0	<0.2	<10	<0.5	2.2			24	11	8000
09-06-83	1400	21.6	7.4	48	8.4	29.5	10.2	29.9	1.0	<0.2	<10	<0.5	2.5					
10-11-83	1325	13.2	7.1	46	9.9	25.0	9.4	24.5	1.0	<0.2	<10	<0.5	2.4			284	134	16200
11-03-83	1345	13.2	7.0	54	9.6	23.4	9.1	23.8	1.0	<0.2	<10	<0.5	2.2					
12-14-83	1300	8.3	6.9	38	11.0	12.3	5.6	18.3	1.0	<0.2	<10	<0.5	3.4			18	5	3500
01-18-84	1315	1.1	6.6	38	14.0	12.1	7.7	16.2	1.0	<0.2	<10	<0.5	1.6					
03-19-84	1350	11.1	7.3	22	10.8	11.9	8.6	17.9	1.0	<0.2	<10	<0.5	1.6			2	1	
04-25-84	1310	14.2	7.3	38	10.0	10.9	5.7	15.1	1.0	<0.2	<10	<0.5	2.4			5	2	
05-17-84	1145	10.7	7.5	43	10.5	14.8	8.4	19.2	1.0	<0.2	<10	<0.5	1.9					
06-26-84	1225	18.7	7.1	60	9.0	25.6	10.8	27.5	1.0	<0.2	<10	<0.5	1.1			200	0	3000
07-30-84	1225	18.8		58	9.4	25.2	12.0	25.8	3.0	<0.2	<10	<0.5	1.1					
08-23-84	1230	21.3	6.6	60	8.4	28.7	11.5	28.6	1.5	<0.2	<10	<0.5	1.6			370	60	11600
09-06-84	1300	16.7	7.2	58	9.4	25.5	9.8	24.7	1.0	<0.2	<10	<0.5	1.4					
10-15-84	1205	15.4	7.3	57	9.8	25.1	9.0	26.1	1.0	<0.2	<10	<0.5	1.2			150	20	
MEAN		13.0	6.9	48	10.3	20.1	8.9	22.7	1.4				2.5			106	26	5397
MEDIAN		13.2	7.1	50	10.0	23.0	9.0	23.8	1.0	<0.2	<10	<0.5	2.3			18	5	3500

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Station Camp Creek, Site SC-4

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
12-14-83	1250															20	9	2200
03-19-84	1330															4	1	
04-25-84	1245															3	2	
06-26-84	1210															100	0	11600
08-23-84	1240															300	0	9800
10-15-84	1235															220	90	
MEAN																108	17	7867
MEDIAN																20	1	9800

STATION NAME White Oak Creek, Site WO-2

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-09-82	1035	6.0	6.7	105	11.2	21.4	13.3	39.8		<0.2			6.0					
12-07-82	1015	10.9	6.1	56	10.7	9.9	12.5	19.6		<0.2	12		7.6					
01-03-83	1025	7.3	6.0	62	11.5	11.5	8.3	24.3		<0.2	16		3.2					
01-31-83	1050	5.9	7.2	77	11.7	13.5	8.4	25.6		<0.2	16		6.4					
03-02-83	955	7.0	7.1	78	11.1	12.8	8.0	28.5		<0.2	21	<0.5	2.7					
04-06-83	950	10.5	6.4	38	9.9	7.3	8.2	14.7		<0.2	12	<0.5	55.0					
05-04-83	1035	12.6	6.7	43	9.4	8.1	8.2	16.0	2.5	<0.2	<10	<0.5	32.0					
06-08-83	1040	16.2	7.1	90	8.2	17.4	9.2	34.0	4.0	<0.2	20	<0.5	13.0					
07-07-83	1020	20.6	6.9	130	5.4	27.1	17.1	44.0	7.0	<0.2	20	<0.5	13.0					
08-04-83	1020	23.3	7.4	240	5.0	56.2	15.8	60.7	14.0	<0.2	32	<0.5	2.8					
MEAN		12.0	6.5	92	9.4	18.5	10.9	30.7	6.9				14.2					
MEDIAN		10.5	6.7	77	9.9	12.8	8.4	25.6	4.0	<0.2	16	<0.5	6.4					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME White Oak Creek, Site WO-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-09-82	945	6.5	6.3	80	11.4	24.0	17.4	39.0		<0.2			3.5					
12-07-82	930	9.6	6.1	53	11.0	10.4	8.0	19.0		<0.2	12		6.9					
01-03-83	955	7.3	6.2	80	11.6	11.1	5.6	23.4		<0.2	14		3.2					
01-31-83	1015	5.9	7.1	72	11.7	12.2	7.7	26.6		<0.2	16		5.4	5.55				
03-02-83	930	6.6	7.2	97	11.4	13.8	8.0	26.8		<0.2	27	<0.5	3.2	6.28				
04-06-83	930	10.5	6.5	21	9.9	7.0	7.5	15.3		<0.2	<10	<0.5	50.0					
04-20-83																60	10	670
05-04-83	1000	12.3	6.6	42	9.7	7.1	7.8	14.3	2.5	<0.2	<10	<0.5		11.30				
06-08-83	1010	14.7	7.1	75	9.0	17.8	8.1	33.2	4.0	<0.2	20	<0.5	8.0	6.02				
06-13-83	1110															30	10	2000
07-07-83	945	19.0	7.1	140	7.7	30.0	13.7	43.6	7.0	<0.2	23	<0.5	8.8	5.35				
08-04-83	955	23.6	7.2	280	5.3	62.7	14.4	69.5	18.0	<0.2	43	<0.5	2.8	5.01				
08-08-83	1035															0	89	38800
09-12-83	1000	21.8	7.3	305	6.2	83.3	25.0	83.1	35.0	<0.2	31	<0.5	2.0	4.92				
10-11-83	1045															4	28	22000
10-24-83	1245	13.5	7.0	255	7.3	57.9	20.0	71.4	16.0	<0.2	27	<0.5	2.5	5.42				
11-17-83	1245	6.5	6.7	118	11.1	24.8	10.9	49.2	6.0	<0.2	26	<0.5	14.0	5.92				
11-29-83	1050															130	328	
12-01-83	1340	6.6	6.6	65	10.8	11.2	6.1	22.7	4.0	<0.2	12	<0.5	5.6	6.58				
01-12-84	940	0.2	6.8	72		11.2	6.7	24.2	3.5	<0.2	12	<0.5	4.3	6.74				
02-08-84	940	0.1	6.3	72	13.4	11.1	8.4	24.5	5.5	<0.2	13	<0.5				3	0	700
03-08-84	950	5.3	7.0	58	12.0	9.8	7.4	21.0	3.5	<0.2	<10	<0.5	8.3					
04-11-84	940	11.3	7.1	68	10.6	10.3	6.2	22.6	3.0	<0.2	14	<0.5	3.4			56	20	340
05-22-84	1300	18.0	7.5	115	9.2	19.3	7.3	34.6	4.0	<0.2	28	<0.5	2.6					
06-07-84	1030	19.5	7.2	125	7.9	22.9	9.6	37.4	3.5	<0.2	25	<0.5	4.5					
07-10-84	1130	20.0		68	7.7	20.0	9.8	32.7	5.5	0.25	16	<0.5	15.0			520	170	13000
08-29-84	1320	22.2	7.4	165	6.9	42.9	15.5	43.0	12.0	<0.2	15	<0.5	2.2			2340	1520	10400
09-20-84	1220	15.9	7.6	270	8.5	67.9	18.3	49.7	27.0	<0.2	13	<0.5	1.4					
10-30-84	1410	17.2	6.5	72	9.1	18.0	10.1	24.3	4.5	0.20	<10	<0.5	3.1			160	10	
MEAN		12.3	6.8	115	9.5	25.3	10.8	35.5	9.1				7.3			330	219	10989
MEDIAN		11.3	7.0	75	9.7	17.8	8.1	26.8	4.5	<0.2	15	<0.5	3.5			56	20	2000

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Williams Creek, Site WL-1 ✓

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-01-82	1425	13.4	6.7	20	9.6													
12-10-82	1150	6.0	5.9	34	11.7	7.1	8.5	13.6		<0.2	<10		2.2					
01-04-83	1155	3.9	6.0	27	12.8	5.6	5.4	14.0		<0.2	11		2.6					
02-22-83	1035	6.3	7.0	31	12.3	5.6	5.0	11.5		<0.2	<10		2.6					
03-23-83	1035	4.7	6.8	40	12.6	5.0	5.4	15.7		<0.2	<10	<0.5	4.1					
04-22-83	1030	7.8	6.6	26	11.9	4.1	4.7	11.4	2.5	<0.2	<10	<0.5	2.9					
05-12-83	1120	13.1	6.6	25	10.0	4.1	7.9	8.9	2.5	<0.2	<10	<0.5	3.0					
06-13-83	1120	16.3	7.0	33	9.3	7.0	7.0	12.1	2.5	<0.2	<10	<0.5	2.4					
07-11-83	1325	20.1	7.2	38	8.8	10.9	6.1	14.6	2.5	<0.2	<10	<0.5	4.5					
08-08-83	1100	22.0	7.4	44	8.1	13.6	9.0	17.5	3.0	<0.2	<10	<0.5	2.6					
09-14-83	1100	18.3	6.7	43	9.0	13.6	8.0	15.3	2.5	<0.2	<10	<0.5	1.6					
10-24-83	1100	13.8	6.6	45	9.5	9.6	7.7	18.5	2.0	<0.2	<10	<0.5	1.6					
MEAN		12.1	6.5	31	10.5	7.2	6.2	12.8	2.2				2.5					
MEDIAN		13.1	6.7	33	9.6	7.0	7.0	14.0	2.5	<0.2	<10	<0.5	2.6					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Williams Creek, Site WL-2

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-11-83	1050	7.9	5.9	34	11.2	11.3	7.3	13.5	1.5	<0.2	<10	<0.5	1.1					
12-13-83	1015	7.9	6.5	36	11.6	6.4	5.1	11.1	1.5	<0.2	<10	<0.5	3.3					
02-17-84	1025	6.7	6.7	32	11.5	5.0	5.6	8.7	1.5	<0.2	<10	<0.5	3.3					
03-13-84	1000	3.9	6.6	20	12.5	4.7	4.5	9.3	1.5	<0.2	<10	<0.5	1.8					
04-04-84	1105	9.2	6.7	21	11.3	3.9	4.5	8.0	1.0	<0.2	<10	<0.5	9.4					
05-16-84	1235	12.1	7.1	25	10.1	5.2	6.3	8.6	1.0	<0.2	<10	<0.5						
06-27-84	1030	18.6	6.8	39	8.8	13.9	8.6	14.1	2.0	<0.2	<10	<0.5	1.5					
07-23-84	1200	20.3	6.2	38	8.4	13.0	11.0	17.3	1.0	0.20	<10	<0.5	2.0					
08-21-84	1045	19.3	6.5		8.5	12.5	9.5	12.5	2.0	<0.2	<10	<0.5	1.5					
10-11-84	1135	15.1	6.4	36	9.1	12.1	8.9	14.1	1.5	0.25	<10	<0.5	2.6					
MEAN		12.1	6.4	31	10.3	8.8	7.1	11.7	1.5				2.9					
MEDIAN		9.2	6.5	34	10.1	6.4	6.3	11.1	1.5	<0.2	<10	<0.5	2.0					

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

STATION NAME Williams Creek, WL-3

DATE	TIME hours	TEMP C	pH	COND umhos /cm	DO mg/l	ALK mg/l	ACID mg/l	HARD mg/l	Cl- mg/l	Fe mg/l	SO4 mg/l	Mn mg/l	TURB NTU	STAGE ft	STREAM FLOW cfs	T COL #/ 100ml	F COL #/ 100ml	F STRP #/ 100ml
11-15-82	1335	6.8	6.4	37	12.1	10.9	9.6	14.0		<0.2	<10		3.0					
12-17-82	1020	8.0	6.0	30	10.2	9.1	5.7	11.1		<0.2	<10		5.5					
01-21-83	1425	2.7	6.5	29	12.8	5.2	5.8	10.5		<0.2	<10		4.5					
02-14-83	1440	5.8	6.6	28	12.1	2.8	5.9	4.9		<0.2	<10		2.6					
03-07-83	1430	12.9	6.9	32	10.1	5.5	5.3	8.9		<0.2	<10		8.3					
04-18-83	1340	7.3	7.0	28	11.5	5.1	5.2	10.7	2.9	<0.2	<10	<0.5	7.7			1070	366	2185
05-09-83	1520	13.0	6.7	25	9.9	6.0	7.4	9.6	2.5	<0.2	<10	<0.5						
06-03-83	915	13.6	6.7	23	9.4	8.7	8.0	12.3	2.5	<0.2	<10	<0.5	3.7					
06-09-83	1455															380	240	5460
07-11-83	1620	21.7	7.0	48	8.3	14.8	8.4	18.4	2.5	<0.2	<10	<0.5	5.2					
08-09-83	1105	19.7		58	6.4	22.5	16.1	24.0	2.0	<0.2	<10	<0.5	4.3			20		10400
09-06-83	1510	22.7	6.8	60	6.6	24.8	11.8	23.9	2.0	<0.2	<10	<0.5	4.5					
10-17-83	1600	13.2	6.7	62	8.7	14.0	11.4	21.6	2.5	<0.2	<10	<0.5	3.0			96	20	14400
11-30-83	1155	5.4	6.3	39	11.9	7.4	7.3	14.9	2.5	<0.2	<10	<0.5	4.0			216	32	11200
02-16-84	1140	6.0	6.5	30	12.1	5.7	6.2	11.4	1.5	<0.2	<10	<0.5	4.9			1	24	
04-26-84	1430	14.8		16	10.3	6.0	5.7	10.4	1.5	<0.2	<10	<0.5	3.4			7	13	
06-29-84	955	17.4	6.9	51	7.9	16.8	11.9	20.1	2.5	0.45	<10	<0.5	2.9			140	140	21600
08-27-84	1345	18.9	7.1	56	8.6	17.4	11.1	18.6	2.0	0.60	<10	<0.5	5.2			360	0	
10-25-84	1335	16.1	6.6	51	9.0	11.1	6.7	15.5	4.5	<0.2	<10	<0.5	3.5					
MEAN		12.6	6.6	39	9.9	10.8	8.3	14.5	2.4				4.5			254	104	10874
MEDIAN		13.0	6.7	32	9.9	8.7	7.3	12.3	2.5	<0.2	<10	<0.5	4.3			140	32	10400

* Note mean values for pH were calculated by converting to microequivalents per liter of the hydrogen ion concentration

APPENDIX B

Location of Sampling Sites, Big South Fork National River and Recreation Area

Table B-1. Locations of monitoring sites in the Big South Fork National River and Recreation Area.

Site	Location	U.S.G.S. Quadrangle
Bandy Creek		
BN-1	Mouth	Honey Creek, TN
BN-2	Upstream side of bridge at Leatherwood Ford Road	Honey Creek, TN
BN-3	Intersection of Bandy Creek and the County line	Honey Creek, TN
Bear Creek		
BR-1	Mouth	Barthell, KY
BR-3	300 m above Slaven Branch	Oneida North, TN-KY
Clear Fork		
CL-1	Mouth	Oneida South, TN
CL-2	USGS gauging station at Burnt Mill Bridge	Honey Creek, TN
CL-3	Brewster Bridge	Rugby, TN
CL-4	100 m upstream of Peters Bridge	Burrville, TN
Difficulty Creek*		
DF-1	Mouth	Oneida North, TN-KY
DF-3	3.7 km upstream of Abre Branch	Barthell SW, TN-KY
Grassy Fork of Williams Creek		
GR-1	Mouth	Oneida North, TN-KY
GR-3	1.6 km upstream of Indian Rock Branch	Oneida North, TN-KY
Laurel Fork of North White Oak Creek		
LN-1	Mouth	Honey Creek, TN
LN-3	Downstream side of Hwy. 154 bridge	Stockton, TN

Table B-1. Continued.

Site	Location	U.S.G.S. Quadrangle
Roaring Paunch Creek		
RP-1	At Barthell	Barthell, KY
RP-3	100 m upstream of Hwy. 742	Whitley City, KY
Rock Creek		
RO-1	0.6 km upstream of mouth	Barthell, KY
RO-2	At Tennessee/Kentucky state line	Barthell SW, TN-KY
RO-3	300 m downstream of Hwy. 154 bridge	Sharp Place, TN-KY
Station Camp Creek		
SC-1	Mouth	Barthell SW, TN-KY
SC-2	200 m upstream of Laurel Fork	Barthell SW, TN-KY
SC-3	20 m upstream of Charit Creek	Barthell SW, TN-KY
SC-4	400 m downstream of Charit Creek	Barthell SW, TN-KY
Troublesome Creek*		
TR-1	Mouth	Oneida North, TN-KY
TR-3	0.8 km upstream of Cliff Branch	Oneida North, TN-KY
White Oak Creek		
WO-2	300 m downstream of Horseshoe Bend	Rugby, TN
WO-3	At old Hwy. 52 bridge	Rugby, TN
Williams Creek		
WL-1	Mouth	Oneida North, TN-KY
WL-2	100 m upstream of Puncheoncamp Fork	Oneida North, TN-KY
WL-3	100 m downstream of Staveyard Hollow at Williams Creek Rd. crossing	Oneida North, TN-KY

*Proposed sampling sites.

Table B-1. Continued.

Site	Location	U.S.G.S. Quadrangle
Laurel Fork of Station Camp Creek		
LS-1	Mouth	Barthell SW, TN-KY
LS-3	100 m upstream of Crooked Branch	Sharp Place, TN-KY
Mill Creek on North White Oak Creek*		
MC-1	Mouth	Stockton, TN
New River		
NR-1	Mouth	Oneida South, TN
NR-3	Downstream of Hwy. 27 at USGS gauging station	Oneida South, TN
No Business Creek		
NB-1	200 m upstream of mouth	Barthell SW, TN-KY
NB-3	200 m downstream of Tacket Creek	Barthell SW, TN-KY
North White Oak Creek		
NW-1	Mouth	Honey Creek, TN
NW-3	300 m upstream of Mill Creek	Stockton, TN
Parch Corn Creek*		
PA-1	Mouth	Barthell SW, TN-KY
PA-3	1.5 km upstream of Middle Prong	Barthell SW, TN-KY
Pine Creek		
PI-1	Mouth	Honey Creek, TN
PI-3	300 m downstream of Toomy at O & W railroad crossing	Oneida South, TN
Puncheoncamp Fork of Williams Creek		
PU-1	Mouth	Oneida North, TN-KY
PU-3	Downstream side of Grave Hill Rd. crossing	Oneida North, TN-KY

APPENDIX C

Fish and Macroinvertebrate Species in the Big South Fork National River and Recreation Area

Table C-1. Fish species collected from tributaries of the Big South Fork National River and Recreation Area, July-September 1981. From: C. J. O'Bara, W. L. Pennington, and W. P. Bonner, 1982.

Family	Scientific Name	Common Name
Petromyzontidae		
	Ichthyomyzon greeleyi	Allegheny Brook Lamprey
Salmonidae		
	Salmo gairdneri	Rainbow Trout
	Salmo trutta	Brown Trout
Cyprinidae		
	Campostoma anomalum	Stoneroller
	Hybopsis amblops	Bigeye Chub
	Nocomis micropogan	River Chub
	Notropis ardens	Rosefin Shiner
	Notropis c. chrysocephalus	Common Shiner
	Notropis galacturus	Whitetail Shiner
	Notropis rubellus	Rosyface Shiner
	Notropis sp.	Sawfin Shiner
	Notropis spilopterus	Spotfin Shiner
	Notropis stramineus	Sand Shiner
	Notropis telescopus	Telescope Shiner
	Notropis volucellus	Mimic Shiner
	Phoxinus erthrogaster	Southern Redbelly Dace
	Rhinichthys atratulus	Blacknose Dace
	Semotilus atromaculatus	Creek Chub
Catostomidae		
	Catostomus commersoni	White Sucker
	Hypentelium nigricans	Northern Hog Sucker
	Moxostoma duquesnii	Black Redhorse
Ictaluridae		
	Ictalurus punctatus	Channel Catfish
	Noturus flavus	Stonecat
	Pylodictis olivaris	Flathead Catfish
Centrarchidae		
	Ambloplites rupestris	Rock Bass
	Lepomis gulosus	Warmouth
	Lepomis macrochirus	Bluegill
	Lepomis megalotis	Longear Sunfish
	Micropterus dolomieui	Smallmouth Bass
	Micropterus punctulatus	Spotted Bass
	Micropterus salmoides	Largemouth Bass

Table C-1. (continued)

Family	Scientific Name	Common Name
Percidae		
	Etheostoma blennioides	Greenside Darter
	Etheostoma caeruleum	Rainbow Darter
	Etheostoma camurum	Bluebreast Darter
	Etheostoma cinereum	Ashy Darter
	Etheostoma maculatum	Spotted Darter
	Etheostoma obeyense	Barcheek Darter
	Etheostoma sagitta	Arrow Darter
	Etheostoma stigmaeum	Speckled Darter
	Percina caprodes	Logperch
	Percina maculata	Blackside Darter
	Percina squamata	Olive Darter
	Stizostedion vitreum	Walleye
Scienidae		
	Aplodinotus grunniens	Freshwater Drum

Table C-2. Benthic macroinvertebrates collected from tributaries of the Big South Fork National River and Recreation Area, July-September 1981. From: C. J. O'Bara, W. L. Pennington, and W. P. Bonner, 1982.

- ANNELIDA
  - Oligochaeta
    - Lumbriculidae
      - *Lumbriculus* sp.
    - Tubificidae
      - *Pelescolex* sp.

  - Hirundinea

- NEMATODA

- NEMATOMORPHA
  - Gordiida

- PLATYHELMINTHES
  - Turbellaria
    - Planariidae

- ARTHROPODA
  - Arachnoidae
    - Hydracarina

  - Crustacea
    - Copepoda
      - Cyclopoida
    - Isopoda
      - Asellidae
        - *Asellus* sp.
        - *Lirceus* sp.
    - Amphipoda
      - Gammaridae
        - *Gammarus* sp.
      - Talitridae
        - *Hyallela azteca*
    - Decapoda
      - Astacidae
        - *Cambarus bartonii*
        - *Cambarus* sp.

  - Insecta
    - Collembola
    - Ephemeroptera
      - Baetidae
        - *Baetis* sp.
        - *Centroptilium* sp.
        - *Pseudocloeon* sp.
      - Baetiscidae
        - *Baetisca berneri*
        - *Baetisca gibbera*
      - Caenidae
        - *Brachycercus* sp.
        - *Caenis* sp.
      - Ephemerellidae
        - *Ephemeralla* (*Drunella*) *longirostris*
        - *Ephemerella* (*Eurylophella*) sp.
        - *Ephemerella* (*Serratella*) sp.
        - *Ephemerella* sp.
      - Ephemeridae
        - *Ephemera* sp.
      - Heptageniidae
        - *Epeorus* sp.
        - *Heptagenia* sp.
        - *Rhithrogenia* sp.
        - *Stenacron* sp.
        - *Stenonema* sp.
      - Leptophlebiidae
        - *Habrophlebia vibrans*
        - *Paraleptophlebia* sp.
      - Neoephemeridae
        - *Neoephemera youngi*
      - Polymitarcyidae
        - *Ephoron album*
      - Siphlonuridae
        - *Ameletus* sp.
        - *Isonychia* sp.
      - Tricorythodae
        - *Tricorythodes* sp.

    - Odonata
      - Anisoptera
        - Aeshnidae
          - *Boyeria* sp.
        - Corduliidae
          - *Neurocordulia* sp.
        - Cordulegastridae
          - *Cordulegaster* sp.
        - Gomphidae
          - *Gomphurus* sp.
          - *Gomphurus rogersi*
          - *Hagenius* sp.
          - *Hagenius brevistylus*

Table C-2. (continued)

- *Lanthus* sp.
- *Ophiogomphus* sp.
- *Stylogomphus* sp.
- Libellulidae
  - *Perithemis* sp.
- Macromiidae
  - *Macromia* sp.
- Zygoptera
  - Calopterygidae
    - *Calopteryx* sp.
    - *Hetaerina* sp.
  - Coenagrionidae
    - *Argia* sp.

- Plecoptera
  - Capniidae
    - *Allocapnia* sp.
    - *Capnia* sp.
  - Chloroperlidae
    - *Hastaperla* sp.
  - Leuctridae
    - *Leuctra* sp.
  - Nemouridae
    - *Amphinemura* sp.
  - Peltoperlidae
    - *Peltoperla* sp.
  - Perlidae
    - *Acroneuria* sp.
    - *Acroneuria abnormis*
    - *Neoperla clymene*
    - *Paragnetina* sp.
    - *Paragnetina immarginata*
    - *Perlesta placida*
    - *Phasganophora* sp.
  - Perlodidae
    - *Isoperla* sp.
  - Pteronarcidae
    - *Allonarcys* sp.
    - *Pteronarcys* sp.
  - Taeniopterygidae
    - *Taeniopteryx* sp.

- Hemiptera
  - Gerridae
    - *Gerris* sp.
    - *Metrobates* sp.
  - Hebridae
  - Saldidae
  - Veliidae
    - *Rhagovelia* sp.

- Megaloptera
  - Corydalidae
    - *Corydalus cornutus*
    - *Nigronia fasciatus*
    - *Nigronia serricornis*
  - Sialidae
    - *Sialis* sp.

- Trichoptera
  - Brachycentridae
    - *Micrasema* sp.
  - Calamoceratidae
    - *Heteroplacton americum*
  - Glossomatidae
    - *Agapetus* sp.
    - *Glossosoma* sp.
    - *Protoptila* sp.
  - Helicopsychidae
    - *Helicopsyche borealis*
  - Hydropsychidae
    - *Cheumatopsyche* sp.
    - *Cheumatopsyche pettiti*
    - *Diplectrona modesta*
    - *Hydropsyche* sp.
    - *Hydropsyche betteni-dreprevada* group
    - *Hydropsyche venularis*
  - Hydroptilidae
    - *Agraylea multipunctata*
    - *Hydroptila* sp.
    - *Leucotrichia pictipes*
    - *Mayatrichia ayama*
    - *Oxyethira* sp.
  - Lepidostomatidae
    - *Lepidostoma* sp.
  - Leptoceridae
    - *Ceraclea* sp.
    - *Oecetis* sp.
    - *Triaenodes* sp.
  - Limnephilidae
    - *Neophylax* sp.
    - *Pycnopsyche* sp.
    - *Pycnopsyche gentilis*
  - Molannidae
    - *Molanna* sp.
  - Odontoceridae
    - *Psilotreta* sp.
  - Philopotamidae
    - *Chimarra atterrima*

Table C-2. (continued)

    - *Dolophiloides distinctus*
    - *Wormaldia* sp.
  - Phryganeidae
    - *Ptilostomis* sp.
  - Polycentropodidae
    - *Neureclipsis* sp.
    - *Neureclipsis crepuscularis*
    - *Polycentropus* sp.
  - Psychomyiidae
    - *Lype diversa*
    - *Psychomyia flavida*
  - Rhyacophilidae
    - *Rhyacophila* sp.

- Coleoptera
  - Dryopidae
    - *Helichus* sp.
    - *Helichus lithophilus*
  - Dytiscidae
    - *Hygrotus* sp.
    - *Hydroporus* sp.
  - Elmidae
    - *Ancyronyx variegata*
    - *Dubiraphia* sp.
    - *Dubiraphia bivittata*
    - *Dubiraphia quadrinotata*
    - *Dubiraphia vittata*
    - *Heterelmis* sp.
    - *Macronychus glabratus*
    - *Microcylloepus* sp.
    - *Microcylloepus pusillus*
    - *Optioservus* sp.
    - *Optioservus fastidatus*
    - *Optioservus ovalis*
    - *Oulimnius latiusculus*
    - *Promesia elegans*
    - *Stenelmis* sp.
  - Gyrinidae
    - *Dineutus* sp.
    - *Gyrinus* sp.
  - Hydrophilidae
    - *Berosus* sp.
    - *Hydroporus* sp.
  - Psephenidae
    - *Ectopria nervosa*
    - *Psephenus herricki*
  - Ptilodactylidae
    - *Anchytarsus bicolor*

- Diptera
  - Ceratopogonidae
    - *Atrichopogon* sp.
    - *Bezzia* sp.
    - *Palpomyia* sp.
  - Chironomidae
    - Chironominae
      - Chironomini
        - *Cryptochironomus fulvus*
        - *Dicrotendipes* sp.
        - *Microtendipes* sp.
        - *Paratendipes* "*connectens*"
        - *Paratendipes subaequalis*
        - *Phaenopsectra obediens*
        - *Polypedilum angulum*
        - *Polypedilum convictum*
        - *Polypedilum fallax*
        - *Polypedilum illinoense*
        - *Stenochironomus* sp.
        - *Stictochironomus devinctus*
        - *Tribelos fuscicornis*
        - *Tribelos jucundus*
      - Tanytarsini
        - *Micropsectra* sp.
        - *Paratanytarsus* sp.
        - *Rheotanytarsus* sp.
        - *Tanytarsus* sp.
        - *Zavrelia* sp.
    - Orthocladiinae
      - *Brillia* sp.
      - *Cardiocladius obscurus*
      - *Corynoneuria* sp.
      - *Cricotopus* sp.
      - *Cricotopus bicinctus*
      - *Diplocladius* sp.
      - *Eukiefferiella bavarica* group
      - *Eukiefferiella claripennis* group
      - *Eukiefferiella coloripes* group
      - *Eukiefferiella pseudomontana* group
      - *Euryhapsis* or *Xylotopus*
      - *Orthocladius* sp.
      - *Parametriocnemus lundbecki*
      - *Psectrocladius psilopterus*
      - *Psectrocladius vernalis*
      - *Pseudorthocladius* sp.
      - *Rheocricotopus* sp.
      - *Synorthocladius* sp.
      - *Synposiocladius* sp.
      - *Thienemanniella xena*

Table C-2. (continued)

- Tanypodinae
  - *Ablabesmyia mallochi*
  - *Ablabesmyia ornata*
  - *Ablabesmyia tarella*
  - *Conchapelopia* sp.
  - *Labrundrinia pilosella*
  - *Larsia* sp.
  - *Nilotanypus* sp.
  - *Procladius* sp.
  - *Zavrelimyia* sp.
- Dixidae
  - *Dixa* sp.
- Dolichopodidae
- Emphididae
- Psychodidae
  - *Pericoma* sp.
- Rhagionidae
  - *Atherix variegata*
- Simulidae
  - *Simulium* sp.
- Tabanidae
  - *Chrysops* sp.
  - *Tabanus* sp.
- Tanyderidae
  - *Protoplasma fitchii*
- Tipulidae
  - *Antocha* sp.
  - *Hexatoma* sp.
  - *Limnophila* sp.
  - *Pseudolimnophila* sp.
  - *Tipula* sp.

- MOLLUSCA
  - Gastropoda
    - Prosobranchia
      - Pleuroceridae
        - *Pleurocera* sp.
    - Pulmonata
      - Ancylidae
        - *Ferrissia* sp.
      - Lymnaeidae
        - *Fossaria* sp.
      - Physidae
        - *Physa* sp.
      - Planoribidae
        - *Gyraulus* sp.

  - Pelecypoda
    - Heterodonta
      - Corbiculidae
        - *Corbicula manilensis*
      - Sphaeriidae
        - *Sphaerium* sp.
        - *Musculium* sp.

APPENDIX D

Locations of Mine Openings in the Big South Fork National River and Recreation Area

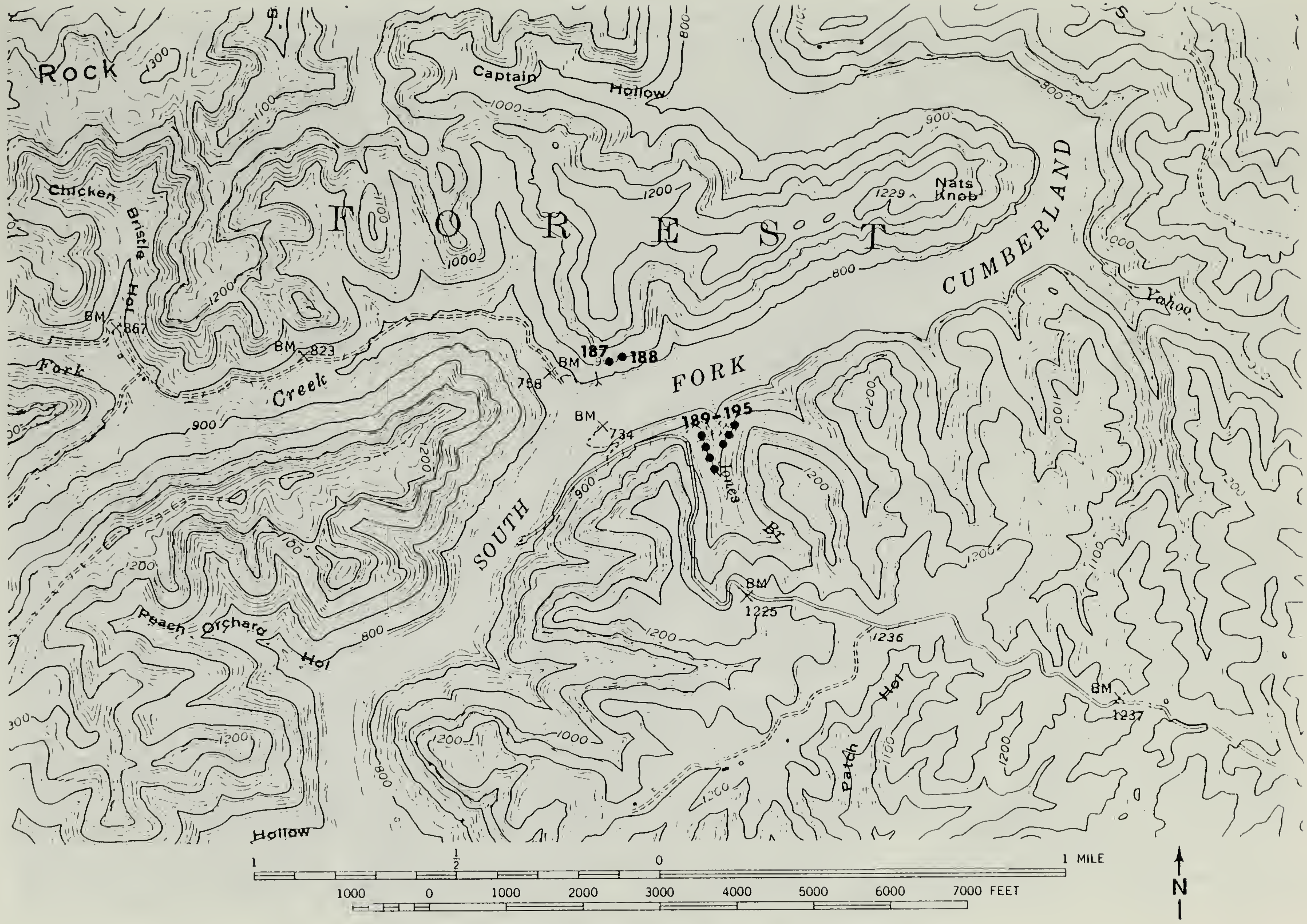

Figure 2. Location of abandoned mine openings in Kentucky portion of the BSFNRRA (1 of 5).

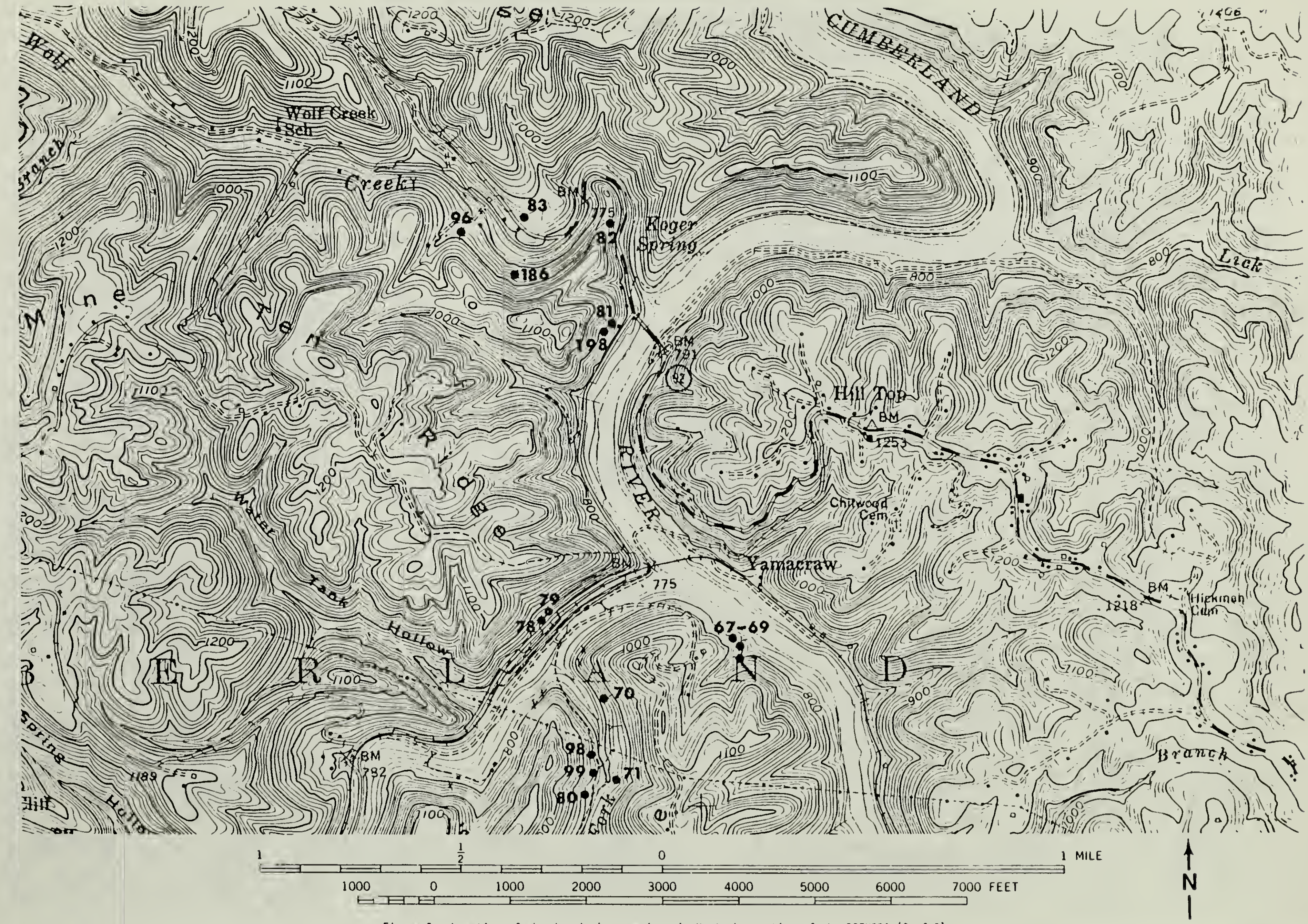

Figure 3. Location of abandoned mine openings in Kentucky portion of the BSFNRRA (2 of 5).

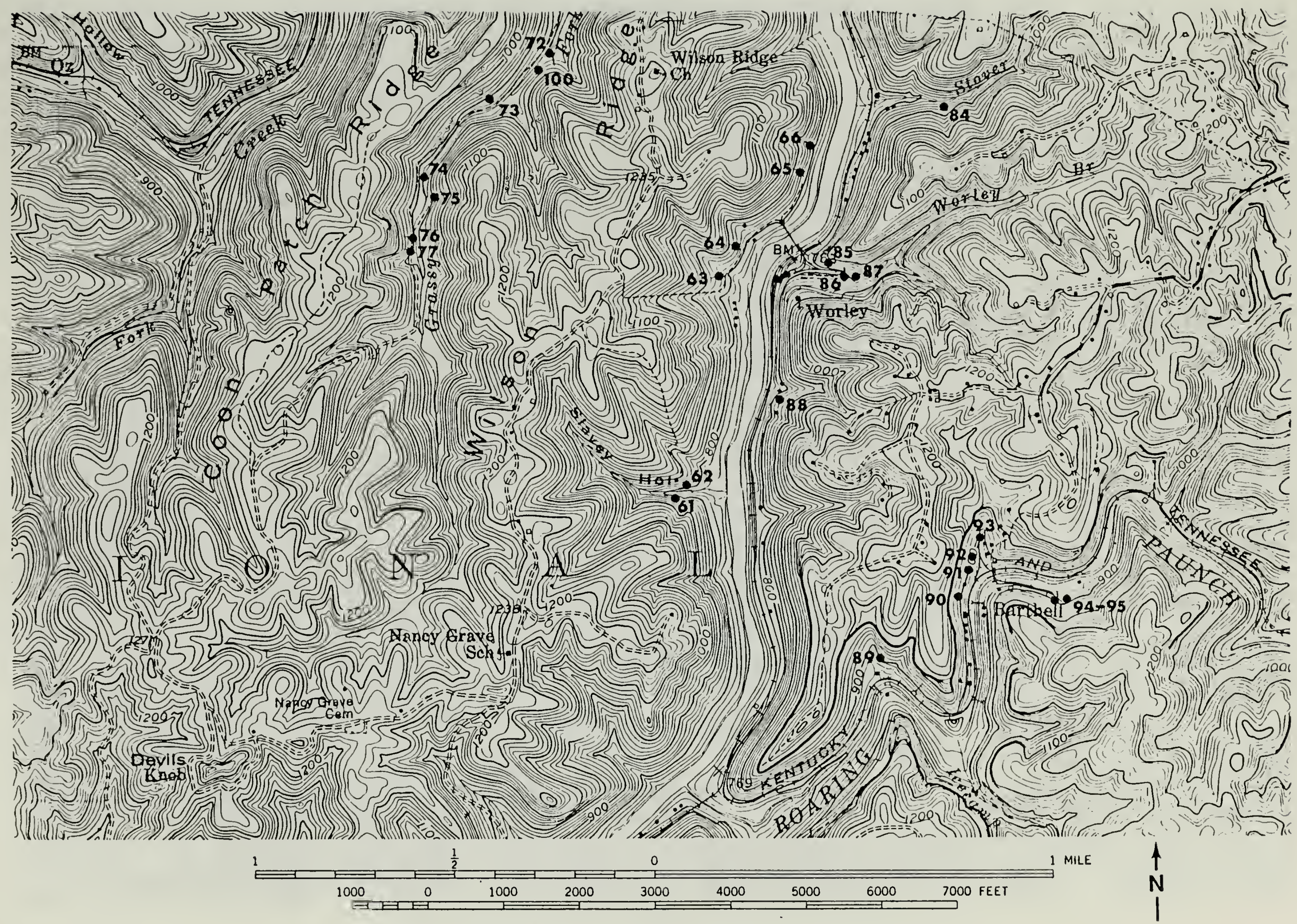

Figure 4. Location of abandoned mine openings in Kentucky portion of the BSFNRRA (3 of 5).

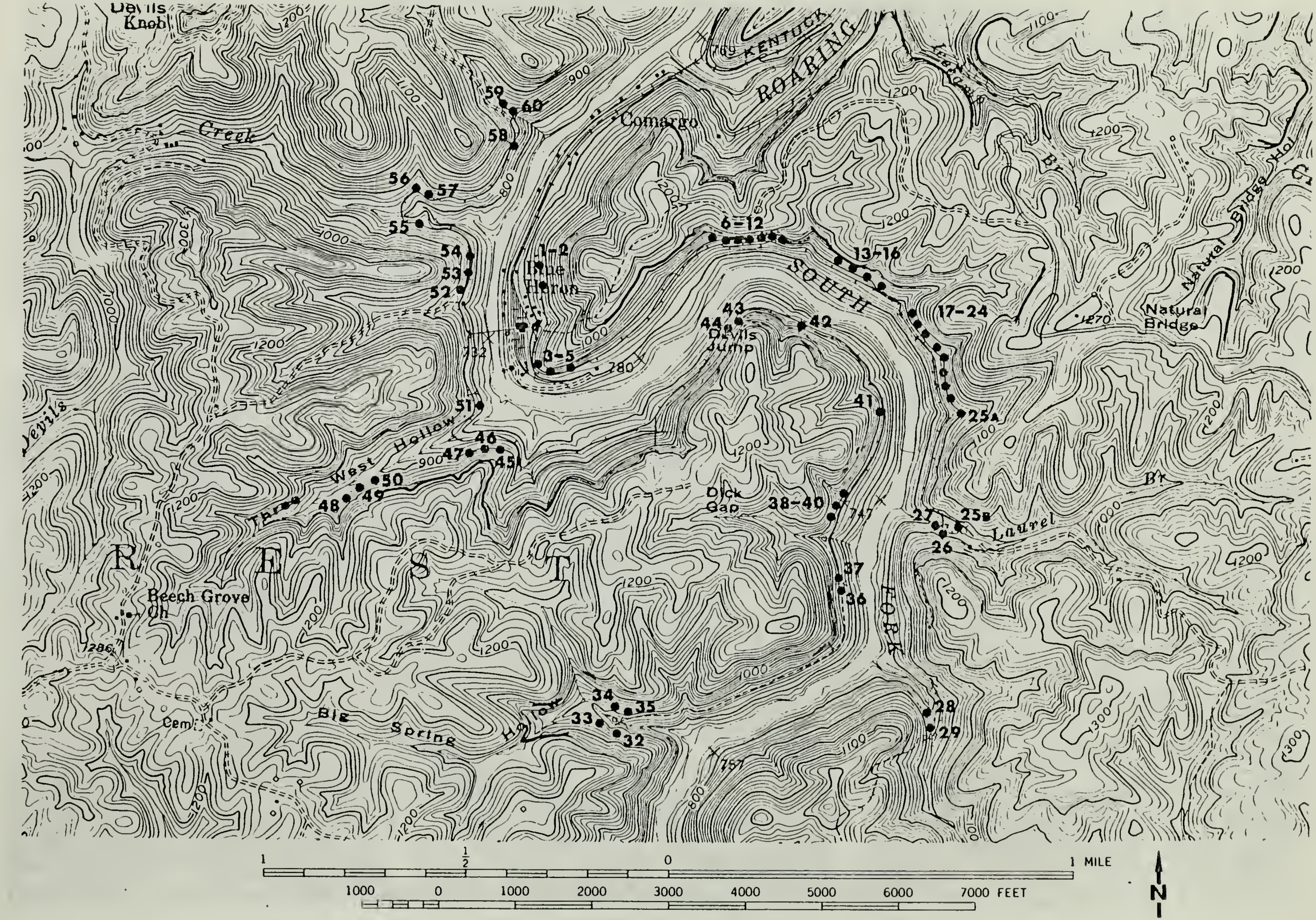

Figure 5. Location of abandoned mine openings in Kentucky portion of the BSFNRRA (4 of 5).

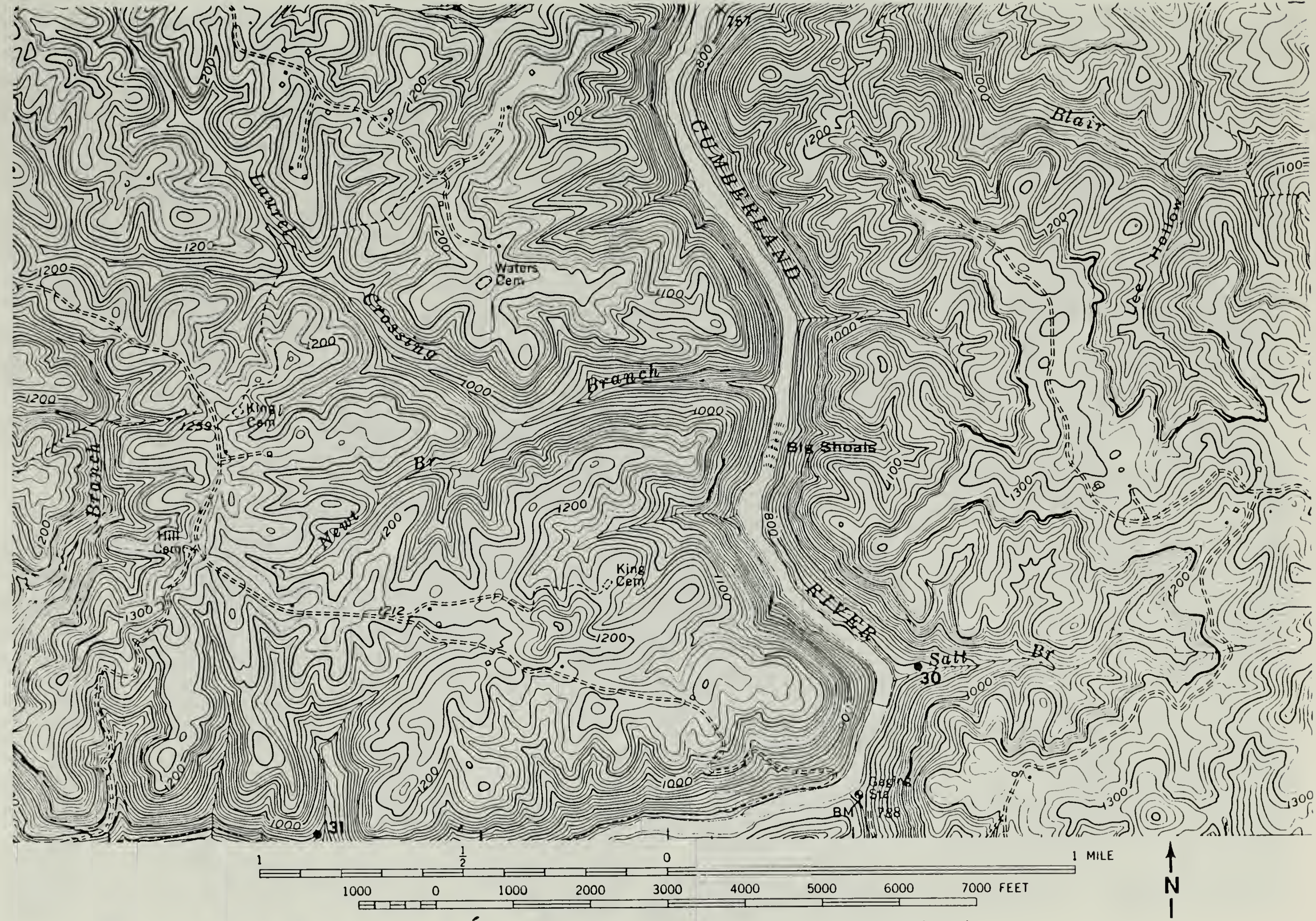

Figure 6. Location of abandoned mine openings in Kentucky portion of the BSFNRRA (5 of 5).

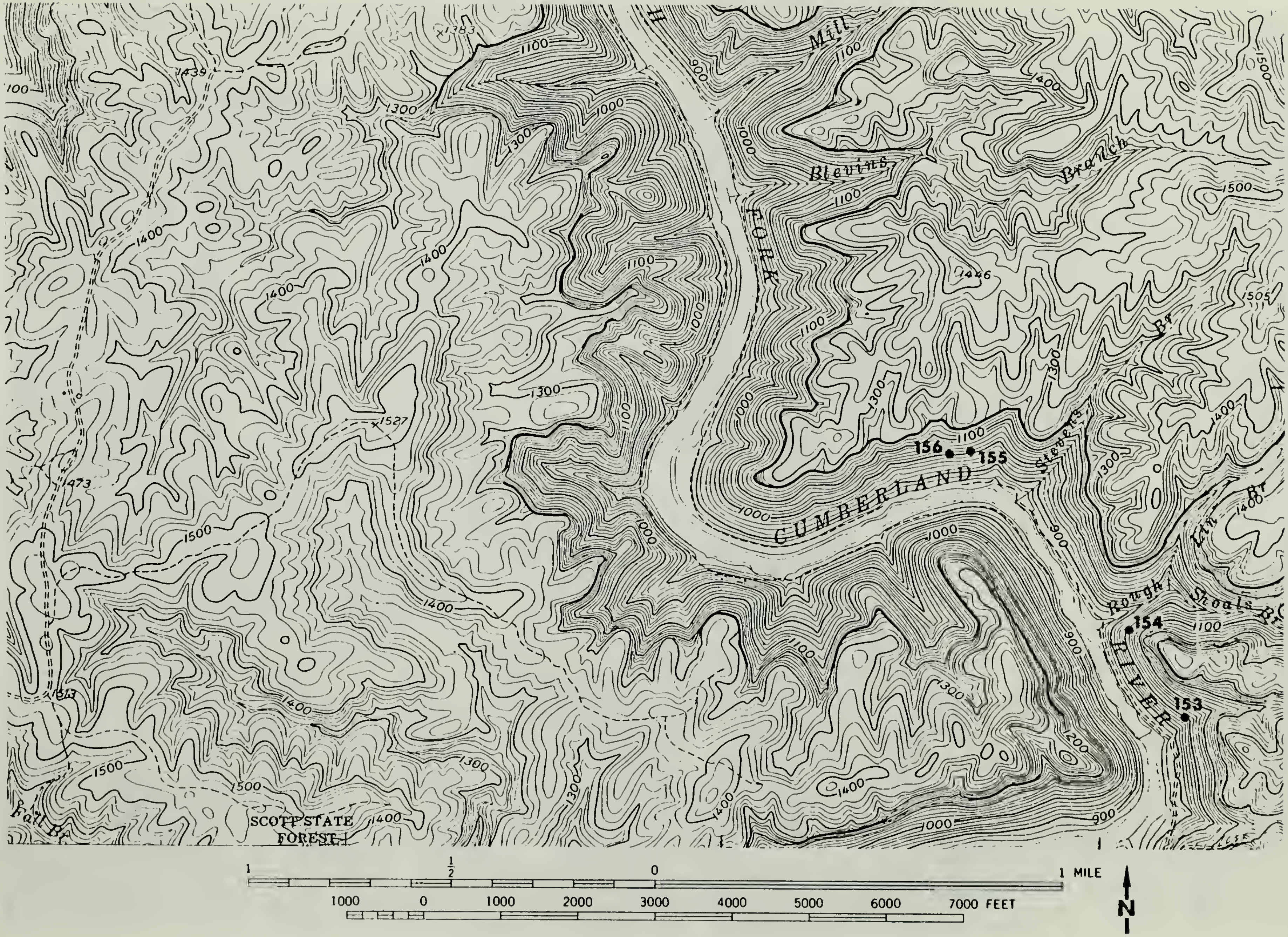

Figure 7. Location of abandoned mine openings in Tennessee portion of the BSFNRRA (1 of 3).

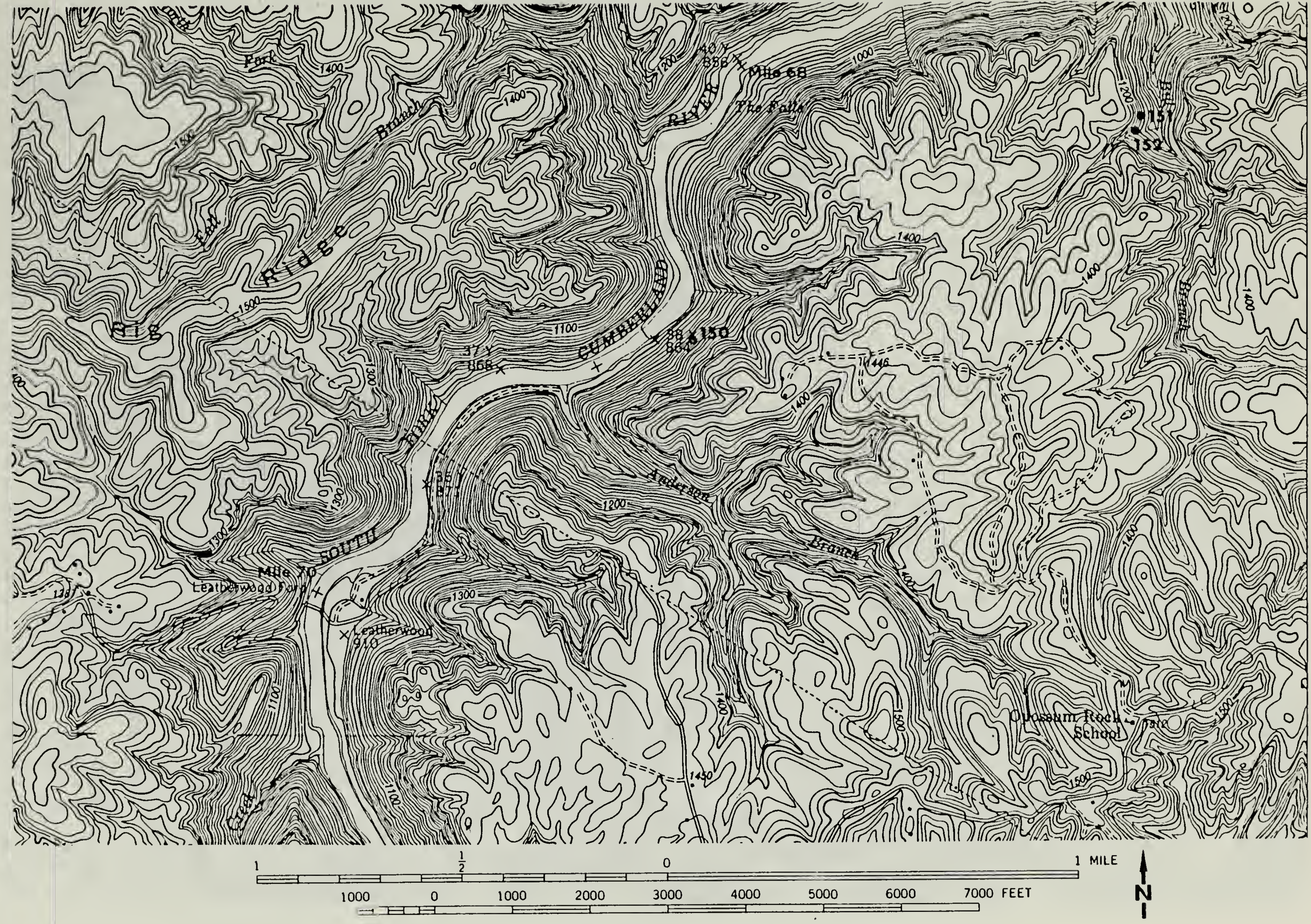

Figure 8. Location of abandoned mine openings in Tennessee portion of the BSFNRRA (2 of 3).

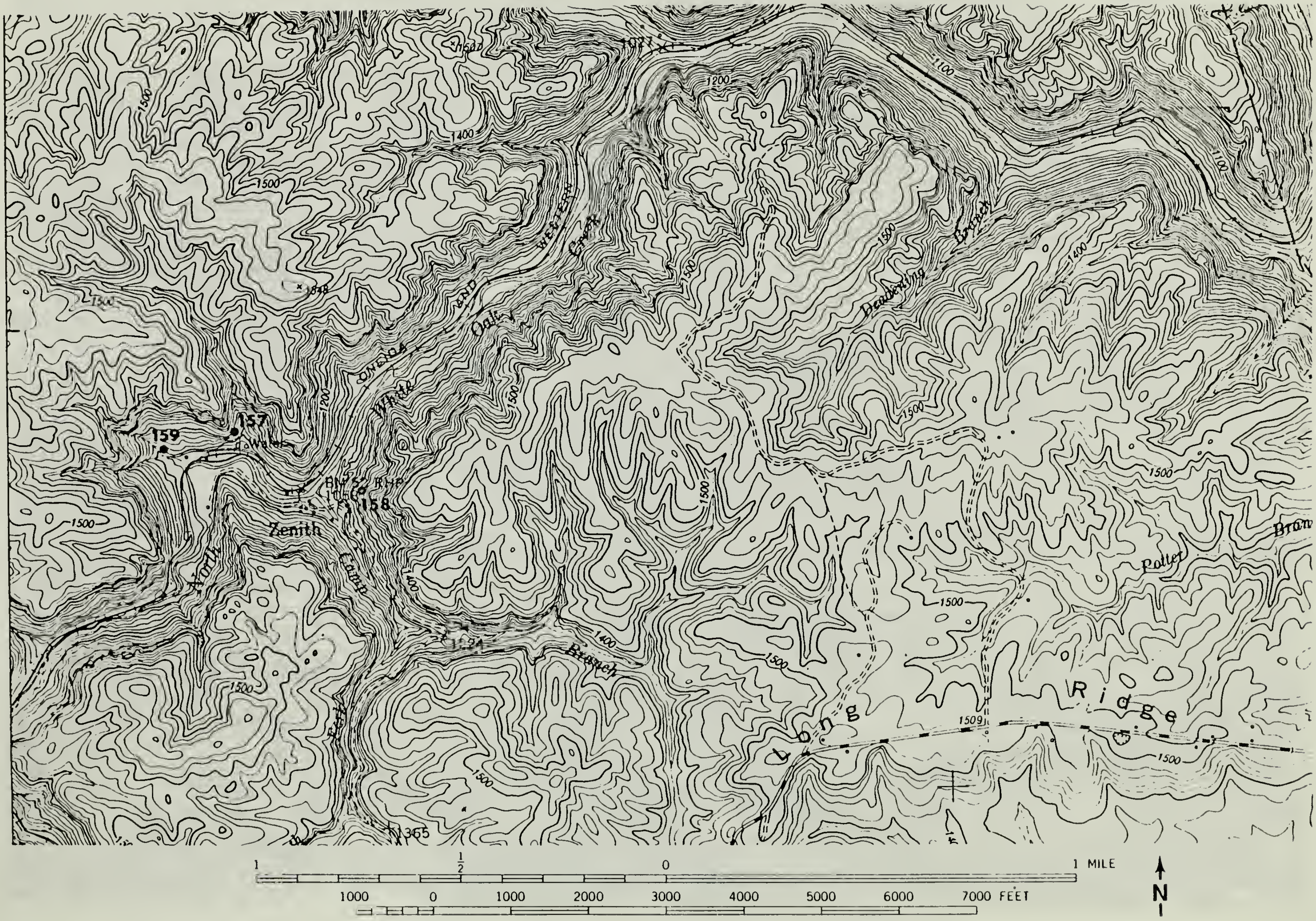

Figure 9. Location of abandoned mine openings in Tennessee portion of the BSFNRRA (3 of 3).

APPENDIX E

Available Water Quality Data for New River Site NR-3, Clear Fork Site CL-2, and USGS Stations New River at New River, TN and Clear Fork near Robbins, TN

Table E-1. Available water quality data for BISO site NR-3 and USGS station New River at New River, TN, October 1982-September 1984.[1] USGS values are mean ($\bar{X}$) or minimum (min) daily values and BISO values are instantaneous readings.

	Conductivity (µmhos/cm)		pH		Dissolved Oxygen (mg/l)		Temperature (°C)	
	BISO	USGS ($\bar{X}$)	BISO	USGS (min)	BISO	USGS ($\bar{X}$)	BISO	USGS ($\bar{X}$)
10-22-82	240	476	7.0	7.4	9.0	9.3	12.7	13.0
12-06-82	140	179	6.8	7.1	9.5	9.4	12.8	13.0
1-13-83	200	217	6.8	7.4	13.7	11.7	5.0	4.0
2-01-83	205	230	7.2	7.4	11.8	11.3	6.4	6.0
3-03-83	210	222	7.9	7.4	10.9	10.8	10.0	8.5
4-12-83	165	172	6.8	7.1	10.7	10.1	10.5	10.0
5-05-83	125	139	6.9	7.1	9.4	9.2	13.1	14.0
6-10-83	260	264	7.6	7.5	8.7	9.0	18.7	19.5
7-05-83	450	440	7.5	7.4	6.9	7.5	25.5	26.0
8-10-83	525	521	7.4	7.3	7.9	6.8	27.6	27.5
9-01-83	450	540	7.4	7.3	7.1	7.3	26.8	26.5
10-18-83	420	422	7.0	7.4	--	8.3	15.0	15.0
11-07-83	470	463	6.8	7.5	10.0	9.6	9.9	10.5
12-01-83	278	213	6.9	7.3	11.2	11.6	6.5	6.5
1-12-84	260	249	7.1	7.8	13.5	13.2	1.2	1.5
2-08-84	265	267	6.9	7.7	14.1	12.9	1.1	0.5
3-15-84	220	236	7.3	7.5	10.9	10.5	8.0	8.5
4-11-84	210	208	6.9	7.3	10.0	9.8	12.5	12.5
5-21-84	300	303	7.5	7.4	8.6	8.6	19.1	19.5
6-07-84	300	309	7.5	7.4	8.4	8.2	24.1	23.0
7-16-84	305	316	7.6	7.3	7.4	7.3	24.7	25.0
8-29-84	450	448	7.7	7.5	7.1	7.7	24.1	24.0
9-17-84	500	485	7.5	7.5	7.9	7.8	19.5	20.0

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[1] Dashes indicate no data available.

Table E-2. Available water quality data for BISO site CL-2 and USGS station Clear Fork near Robbins, TN, October 1983-October 1984.[1] USGS values are mean ($\bar{X}$) or minimum (min) daily values and BISO values are instantaneous readings.

	Conductivity (µmhos/cm)		pH		Dissolved Oxygen (mg/l)		Temperature (°C)	
	BISO	USGS ($\bar{X}$)	BISO	USGS (min)	BISO	USGS ($\bar{X}$)	BISO	USGS ($\bar{X}$)
[USGS Station Clear Fork near Robbins, TN, not in operation until October 1983.]								
10-24-83	113	109	5.8	7.0	8.6	8.2	14.5	15.5
11-17-83	136	--	6.4	--	11.3	--	6.4	--
12-01-83	65	58	6.3	6.7	11.2	11.1	6.2	7.0
1-12-84	64	58	6.6	6.9	14.0	13.8	0.4	1.0
2-08-84	67	57	6.7	6.9	13.8	13.9	0.6	0.5
3-08-84	57	50	7.1	6.8	12.6	11.8	5.7	6.0
4-11-84	48	44	7.0	6.7	10.7	10.4	12.2	12.0
5-22-84	56	54	7.2	6.9	8.4	8.9	18.9	20.0
6-07-84	77	64	7.3	6.9	8.3	8.0	23.8	23.0
7-10-84	70	72	--	6.9	8.1	7.3	24.9	24.5
8-29-84	112	93	7.4	7.0	7.8	7.4	24.1	25.0
9-20-84	102	98	6.9	7.1	7.6	8.2	17.1	20.5
10-30-84	78	69	5.9	7.0	9.0	9.2	16.8	17.3

[1] Dashes indicate no data available.

APPENDIX F

State of Tennessee Water Quality Criteria and Stream Use Classifications for Interstate and Intrastate Streams

TENNESSEE'S WATER QUALITY CRITERIA AND STREAM USE CLASSIFICATIONS FOR INTERSTATE AND INTRASTATE STREAMS

August 1983

Tennessee Water Quality Control Board
Department of Health and Environment
150 9th Avenue, N.
Nashville, Tennessee 37203

RULES OF
TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT
BUREAU OF ENVIRONMENT
DIVISION OF WATER MANAGEMENT

CHAPTER 1200-4-3

GENERAL WATER QUALITY CRITERIA

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1200-4-3 General Water Quality Criteria

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1200-4-3 GENERAL WATER QUALITY CRITERIA

1200-4-3-.01 TENNESSEE WATER QUALITY CONTROL BOARD

The Water Quality Control Act, Tennessee Code Annotated, Sections 69-3-101, et seq., makes it the duty of the Water Quality Control Board to study and investigate all problems concerned with the pollution of the waters of the State and with its prevention, abatement, and control; and to establish such standards of quality for any waters of the State in relation to their reasonable and necessary use as the Board shall deem to be in the public interest; and establish general policies relating to pollution as the Board shall deem necessary to accomplish the purposes of the Act. The following general considerations and criteria shall be used to determine the permissible conditions of waters with respect to pollution and preventive or corrective measures required to control pollution in various waters or in different sections of the same waters.

Statutory Authority: T.C.A. Section 69-3-105.

1200-4-3-.02 GENERAL CONSIDERATIONS

(1) Tennessee water quality standards shall consist of the General Water Quality Criteria, Rule 1200-4-3, and the Stream Use Classifications found in Rule 1200-4-4.

(2) Waters have many uses which in the public interest are reasonable and necessary. Such uses include: sources of water supply for domestic and industrial purposes; propagation and maintenance of fish and other desirable aquatic life; recreation in and on the waters; stock watering and irrigation; navigation; generation of power; and the enjoyment of scenic and aesthetic qualities of waters.

(3) The rigid application of uniform water quality is not desirable or reasonable because of the varying uses of such waters. The assimilative capacity of a stream for sewage and waste varies depending upon various factors and including the following: volume of flow, depth of channel, the presence of falls or rapids, rate of flow, temperature, natural characteristics, and the nature of the stream. Also, the relative importance assigned to each use will differ for different waters and sections of waters.

(4) In order to permit the reasonable and necessary uses of the waters of the State, existing pollution should be corrected as rapidly as practicable, and future pollution prevented through the best available technology economically achievable or that greater level of technology necessary to meet water quality standards; i.e., treatment plants or other control measures. There is an economical balance between the cost of sewage and waste treatment and the benefits received inherent in the correction and prevention of present and future pollution.

(5) Sewage, industrial wastes, or other wastes, as defined in the Water Quality Control Act, Tennessee Code Annotated, Sections 69-3-101, et. seq., shall not be discharged into or adjacent to streams or other surface waters in

such quantity and of such character or under such conditions of discharge in relation to the receiving waters as will result in visual or olfactory nuisances, undue interference to other reasonable and necessary uses of the water, or appreciable damage to the natural processes of self-purification. In relation to the various qualities and the specific uses of the receiving waters, no sewage, industrial wastes, or other wastes discharged shall be responsible for conditions that fail to meet the water quality standards outlined herein. By-passing or accidental spills may be permitted only where necessary to prevent loss of life or severe property damage, or where excessive storm drainage or runoff would damage treatment facilities, and where it is not a routine operation of the facility.

(6) Since all waters of the State are classified for more than one use, the most stringent criteria will be applicable.

Statutory Authority: T.C.A. 69-3-105.

1200-4-3-.03 CRITERIA FOR WATER CONDITIONS

(1) Domestic Water Supply

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - The hardness of or the mineral compounds contained in the water shall not appreciably impair the usefulness of the water as a source of domestic water supply.

(d) Total Dissovled Solids - The total dissolved solids shall at no time exceed 500 mg/l.

(e) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water as a source of domestic water supply.

(f) Turbidity or Color - There shall be no turbidity or color in amounts or characteristics that cannot be reducted to acceptable concentrations by conventional water treatment processes.

(g) Temperature - The maximum water temperature change shall not exceed 3C° relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2C° per hour. The temperature of impoundments where stratification occurs will be measured at a depth of 5 feet, or mid-depth whichever is less, and the temperature in flowing streams shall be measured at mid-depth.

(h) Coliform - The concentration of the fecal coliform group shall not exceed 1,000 per 100 ml. as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purpose of determining the geometric mean, individual samples having a fecal coliform group concentration of less than 1 per 100 ml. shall be considered as having a concentration of 1 per 100 ml. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 5,000 per 100 ml.

(i) Taste or Odor - The waters shall not contain substances which will result in taste or odor that prevent the production of potable water by conventional water treatment processes.

(j) Toxic.Substances - The waters shall not contain toxic substances whether alone or in combination with other substances, which will produce toxic conditions that materially affect the health and safety of man or animals, or impair the safety of conventionally treated water supplies. Available references to be used in determining such conditions shall include, but not limited to; Quality Criteria for Water (Section 304(a) of Public Law 92-500); Federal Regulations under Section 307 of Public Law 92-500; and Federal Regulations under Section 1412 of the Public Health Service Act as amended by the Safe Drinking Water Act, (Public Law 93-523). Limits set for some of the most commonly occurring toxic substances are as follows:

Parameter	Criteria (ug/L)
Cadmium	10
Chromium (total)	50
Copper	1,000
Lead	50
Mercury	0.2
Nickel	100
Selenium	10
Silver	50
Zinc	5,000
Cyanide	200

(k) Other Pollutants - The waters shall not contain other pollutants in quantities that may be detrimental to public health or impair the usefulness of the water as a source of domestic water supply.

(2) Industrial Water Supply

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - The hardness of or the mineral compounds contained in the water shall not appreciably impair the usefulness of the water as a source of industrial water supply.

(d) Total Dissolved Solids - The total dissolved solids shall at no time exceed 500 mg/l.

(e) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water as a source of industrial water supply.

(f) Turbidity or Color - There shall be no turbidity or color in amounts or characteristics that cannot be reduced to acceptable concentrations by conventional water treatment processes.

(g) Temperature - The maximum water temperature change shall not exceed 3C° relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2C° per hour. The temperature of impoundments where stratification occurs will be measured at a depth of 5 feet, or mid-depth whichever is less, and the temperature in flowing streams shall be measured at mid-depth.

(h) Taste or Odor - The waters shall not contain substances which will result in taste or odor that would prevent the use of the water for industrial processing.

(i) Toxic Substances - The waters shall not contain toxic substances whether alone or in combination with other substances, which will adversely affect industrial processing.

(j) Other Pollutants - The waters shall not contain other pollutants in quantities that may adversely affect the water for industrial processing.

(3) Fish and Aquatic Life

(a) Dissolved Oxygen - The dissolved oxygen shall be a minimum of 5.0 mg/l except in limited sections of streams where it can be clearly demonstrated that (i) the existing quality of the water due to irretrievable man-induced conditions cannot be restored to the desired minimum of 5.0 mg/l dissolved oxygen; (ii) the cost for application of effluent limitations more stringent than those defined through Section 301 (b) of the Federal Water Pollution Control Act (PL 92-500) is economically prohibitive when compared with the benefits to be obtained; or (iii) the natural background quality of the water is less than the desired minimum of 5.0 mg/l. Such exceptions shall be determined on an individual basis, but in no instance shall the dissolved oxygen concentration be less than 3.0 mg/l. The dissolved oxygen concentrations shall be measured at mid-depth in waters having a total depth of ten (10) feet or less, and at a depth of five (5) feet in waters having a total depth of greater than ten (10) feet. The dissolved oxygen concentration of recognized trout streams shall not be less than 6.0 mg/l.

(b) pH - The pH value shall lie within the range of 6.5 to 8.5 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character that may be detrimental to fish and aquatic life.

(d) Turbidity or Color - There shall be no turbidity or color in such amounts or of such character that will materially affect fish and aquatic life.

(e) Temperature - The maximum water temperature change shall not exceed 3C° relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2C° per hour. The temperature of recognized trout waters shall not exceed 20°C. There shall be no abnormal temperature changes that may affect aquatic life unless caused by natural conditions. The temperature of impoundments where stratification occurs will be measured at mid-depth in the epilimnion for warm water fisheries and mid-depth in the hypolimnion for cold water fisheries. In the case of large impoundments (100 acres or larger) subject to stratification and recognized as trout waters, the temperature of the hypolimnion shall not exceed 20°C. The temperature in flowing streams shall be measured at mid-depth.

(f) Taste or Odor - The waters shall not contain substances that will impart unpalatable flavor to fish or result in noticeable offensive odors in the vicinity of the water or otherwise interfere with fish or aquatic life.

(g) Toxic Substances - The waters shall not contain substances, whether alone or in combination with other substances, that will adversely affect fish or aquatic life. The in-stream concentrations of toxic pollutants shall not exceed 1/10 of the 96-hour LC_{50} based upon available data using one or more of the most sensitive organisms significant to the aquatic community of the waters under consideration. In no event shall the diversity or productivity of biota significant to the aquatic community of the receiving stream be decreased based upon a 96-hour LC_{50} criterion and the appropriate application factor. References to be used in determining toxicity limitations shall include but not be limited to: Quality Criteria for Water (Section 304(a) of Public Law 92-500), Federal Regulations under Section 307 of Public Law 92-500, and Federal Regulations under Section 1412 of the Public Health Service Act as amended by the Safe Drinking Water Act (Public Law 93-523). The use of such information should be limited to that part applicable to the aquatic community found within the receiving stream or waters under consideration.

(h) Other Pollutants - The waters shall not contain other pollutants that will be detrimental to fish or aquatic life.

(i) Coliform - The concentration of the fecal coliform group shall not exceed 1,000 per 100 ml. as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group concentration of less than 1 per 100 ml. shall be considered as having a concentration of 1 per 100 ml. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 5,000 per 100 ml.

(4) Recreation

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character that may be detrimental to recreation.

(d) Turbidity or Color - There shall be no turbidity or color in such amounts or character that will result in any objectionable appearance to the water.

(e) Temperature - The maximum water temperature change shall not exceed 3C° relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2C° per hour. The temperature of impoundments where stratification occurs will be measured at a depth of 5 feet, or mid-depth whichever is less, and the temperature in flowing streams shall be measured at mid-depth.

(f) Coliform - The concentration of a fecal coliform group shall not exceed 200 per 100 ml. as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group concentration of less than 1 per 100 ml. shall be considered as having a concentration of 1 per 100 ml. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 ml. Water areas in the vicinity of domestic wastewater treatment plant outfalls are not considered suitable for body contact recreational purposes.

(g) Taste or Odor - The waters shall not contain substances that will result in objectionable taste or odor.

(h) Toxic Substances - The waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities, or will propose toxic conditions that will adversely affect man or animal.

(i) Other Pollutants - The waters shall not contain other pollutants in quantities which may have a detrimental effect on recreation.

(5) Irrigation

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - The hardness of or the mineral compounds contained in the water shall not impair its use for irrigation.

(d) Solids, Floating Materials and Deposits - There shall be not distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water for irrigation purposes.

(e) Temperature - The temperature of the water shall not interfere with its use for irrigation purposes.

(f) Toxic Substances - The waters shall not contain toxic substances whether alone or in combination with other substances which will produce toxic conditions that adversely affect the quality of the waters for irrigation.

(g) Other Pollutants - The waters shall not contain other pollutants in quantities which may be detrimental to the waters used for irrigation.

(6) Livestock Watering and Wildlife

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - The hardness of or the mineral compounds contained in the water shall not impair its use for livestock watering and wildlife.

(d) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as to interfere with livestock watering and wildlife.

(e) Temperature - The temperature of the water shall not interfere with its use for livestock watering and wildlife.

(f) Toxic Substances - The waters shall not contain substances whether alone or in combination with other substances, which will produce toxic conditions that adversely affect the quality of the waters for livestock watering and wildlife.

(g) Other Pollutants The waters shall not contain other pollutants in quantities which may be detrimental to the water for livestock watering and wildlife.

(7) Navigation

(a) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as to interfere with navigation.

(b) Other Pollutants - The waters shall not contain other pollutants in quantities which may be detrimental to the waters used for navigation.

Statutory Authority: T.C.A. Section 69-3-105.

1200-4-3-.04 DEFINITIONS

(1) Conventional Water Treatment - Conventional water treatment as referred to in the criteria denotes coagulation, sedimentation, filtration or chlorination.

(2) Mixing Zone - Mixing zone refers to that section of a flowing stream or impounded waters necessary for an effluent to become dispersed and mixed insofar as practical with the main flow or water body by appropriate methods at the discharge point. Such zones shall be restricted to as small an area and length as possible and shall not (i) prevent the free passage of fish or cause aquatic life mortality in the receiving waters; (ii) contain materials, that adequately represent the defined zone, in concentrations that exceed the 96-hour LC_{50} for biota significant to the aquatic community in the receiving waters; (iii) result in offensive conditions; (iv) produce undesirable aquatic life or result in dominance of a nuisance species; (v) endanger the public health or welfare; or (vi) adversely affect the reasonable and necessary uses of the area.

(3) Terminology not specifically defined herein shall be defined in accordance with the Tennessee Water Quality Control Act, (T.C.A. Sections 69-3-101, et seq.).

Statutory Authority: T.C.A. Section 69-3-105.

1200-4-3-.05 INTERPRETATION OF CRITERIA

(1) Interpretation of the above criteria shall conform to any rules and regulations or policies adopted by the Water Quality Control Board.

(2) Insofar as practicable, the effect of treated sewage or waste discharge on the receiving waters shall be considered after they are mixed with the waters and beyond a reasonable zone of immediate effect. The extent to which this is practicable depends upon local conditions and the proximity and nature of other uses of the waters.

(3) The technical and economical feasibility of waste treatment, recovery, or adjustment of the method of discharge to provide correction shall be considered in determining the time to be allowed for the development of practicable methods and for the specified correction.

(4) The criteria set forth shall be applied on the basis of the following stream flows: unregulated streams - stream flows equal to or exceeding the 3-day minimum, 20 year recurrence interval; regulated streams - all flows in excess of the minimum critical flow occurring once in twenty (20) years as determined by an analysis of records of operation and approved by the Commissioner of the Tennessee Department of Health and Environment.

(5) In general, deviations from normal water conditions are undesirable, but the rate and extent of the deviations shall be considered in interpreting the above criteria.

(6) The criteria and standards provide that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., Sections 69-3-101, et seq.).

(7) Where naturally occurring or background water quality conditions are substantial impediments to attainment of the water quality standards, these natural or background conditions shall be taken into consideration in establishing any effluent limitations or restrictions on discharges to such waters.

Statutory Authority: T.C.A. Section 69-3-105.

1200-4-3-.06 TENNESSEE ANTIDEGRADATION STATEMENT

(1) The purpose of the Water Quality Standards and Plans as adopted are to provide for the protection of existing water quality; and/or the upgrading or "enhancement of water quality in all waters within Tennessee; and to protect the public health or welfare in accordance with the public interest". The latest edition of Quality Criteria for Water published by the Environmental

Protection Agency pursuant to Section 304(a) of the Federal Water Pollution Control Act (Public Law 92-500) and other documents as specified by the Commissioner of the Tennessee Department of Health and Environment and the Water Quality Control Board, shall be used as guides in interpreting the water quality criteria set out in these rules.

(2) The Tennessee Water Quality Standards shall not be construed as permitting the degradation of waters whose existing quality is better than the established standards unless and until it is affirmatively demonstrated to the Tennessee Water Quality Control Board that a change is justifiable as a result of necessary economic or social development and will not interfere with or become injurious to any assigned uses made of such waters. In no case will water quality be degraded below the base levels set forth in the criteria for the protection of the reasonable and necessary uses described herein. Additionally, no degradation shall be allowed in high quality waters which constitute an outstanding national resource, such as; waters of National and State parks and wildlife refuges, and waters of exceptional recreational or ecological significance.

(3) All discharges of municipal sewage, industrial waste, or other wastes shall receive the greatest degree of effluent reduction which the Commissioner of the Tennessee Department of Health and Environment determines to be achievable through application of stringent effluent limitations and schedules of compliance either promulgated by the Water Quality Control Board; required to implement any applicable water quality standards, including where practicable, a standard permitting no discharge of pollutants; necessary to comply with a State Water Quality Plan; or necessary to comply with other State or Federal laws or regulations.

(4) In implementing the provisions of these rules as they relate to interstate streams, the Commissioner of the Tennessee Department of Health and Environment and the Tennessee Water Quality Control Board will cooperate with the appropriate Federal Agency in order to assist in carrying out responsibilities under the Federal Water Pollution Act, as amended.

Statutory Authority: T.C.A. Section 69-3-105.

TW/vsp/Wat/Regs/1
7/29/83

Rules of

Tennessee Department of Health and Environment
Bureau of Environment
Division of Water Management

CHAPTER 1200-4-4

Stream Use Classfications for Interstate and Intrastate Streams

AUGUST 1983

(13) Upper Cumberland River Basin

STREAM	DESCRIPTION	DOM	IND	FISH	REC	IRR	LW&W	NAV
Wilkerson Creek	Mile 2.6 to Origin			X	X	X	X	
Frey Branch	Mile 0.0 to 0.2			X		X	X	
Frey Branch	Mile 0.2 to Origin			X	X	X	X	
Roaring River	Mile 0.0 to Origin			X	X	X	X	
Spring Creek	Mile 0.0 to Origin			X	X	X	X	
Bear Creek	Mile 0.0 to 4.3			X	X	X	X	
Bear Creek	Mile 4.3 to 6.4			X		X	X	
Bear Creek	Mile 6.4 to Origin			X	X	X	X	
Carr Creek	Mile 0.0 to 4.2			X	X	X	X	
Carr Creek	Mile 4.2 to Origin	X		X	X	X	X	
Town Creek	Mile 0.0 to 0.8			X		X	X	
Town Creek	Mile 0.8 to Origin			X	X	X	X	
Obey River	Mile 0.0 to 57.2 (Confluence-East & West Fork)	X	X	X	X	X	X	
Wolf River	Mile 0.0 to Ky-Tenn State Line		X	X	X	X	X	
Town Creek	Mile 0.0 to 0.9			X		X	X	
Town Creek	Mile 0.9 to Origin			X	X	X	X	
West Fork Obey River	Mile 0.0 to Origin			X	X	X	X	
East Fork Obey River	Mile 0.0 to Origin			X	X	X	X	
Buffalo Cove Creek	Mile 0.0 to Origin			X	X	X	X	
Rock Castle Creek	Mile 0.0 to 4.0			X	X	X	X	
Rock Castle Cr.	Mile 4.0 to 5.5			X		X	X	
Rock Castle Cr.	Mile 5.5 to Origin			X	X	X	X	
– Big South Fork Cumberland River	Mile 55.5 (Ky-Tenn Line) to Origin (Mile 77.0)	X	X	X	X	X	X	
– Pine Creek	Mile 0.0 to 8.5			X	X	X	X	
– Pine Creek	Mile 8.5 to 10.5			X		X	X	
– Pine Creek	Mile 10.5 to Origin	X		X	X	X	X	
– New River	Mile 0.0 to Origin			X	X	X	X	

(13) Upper Cumberland River Basin

STREAM	DESCRIPTION	DOM	IND	FISH	REC	IRR	LW&W	NAV
— Clear Fork River	Mile 0.0 to Origin			X	X	X	X	
All other streams within the Upper Cumberland River Basin, named and unnamed, which have not been specifically treated shall be classified				X	X	X	X	

(Trout Streams)

STREAM	COUNTY	DESCRIPTION
Goose Creek	C Trousdale	Mile 0.0 to 12.0
	S Macon	
Flynns Creek	S Jackson	Mile 0.0 to 5.0
— No ~~North~~ Business Creek	NW Scott	Upper Section (4.0 Miles)
—Parch Corn Creek	NW Scott	Upper Section (1.5 Miles)
— Station Camp Creek	NW Scott	Upper Section (4.8 Miles)
— Laurel Fork Creek	NW Scott	Upper Section (4.9 Miles)
— North White Oak Creek	EC Fentress	Upper Section (3.9 Miles)
— Williams Creek	NW Scott	Upper Section (7.6 Miles)
Obey River	C Clay	Mile 0.0 to 7.3
Neely Creek	C Clay	Mile 0.0 to Origin (3.3 Miles)
Wolf River	C Pickett	5.3 Miles Downstream from Fentress County Line to Origin (17.2 Miles)
Caney Fork River		Mile 25.4 to 26.6 (Center Hill Dam)
Dry Creek		Mile 0.0 to Origin
Jones Fork		Mile 0.0 to Origin
Pine Creek		Mile 2.4 to Origin
Turner Branch		Mile 0.0 to 0.5
Sink Creek		Mile 4.6 to Origin
Mountain Creek		Mile 0.0 to 6.0